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Lake and River Enhancement Section
Division of Fish and Wildlife/IDNR
402 W. Washington Street, W-273
Indianapolis, IN 46204

Union Mills :

**A Study for the Improvement,
Restoration, and Protection of
Mill Pond...**

Prepared for:

**Save Our Pond Committee
Union Mills, IN 46382**

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Acknowledgments/Credits

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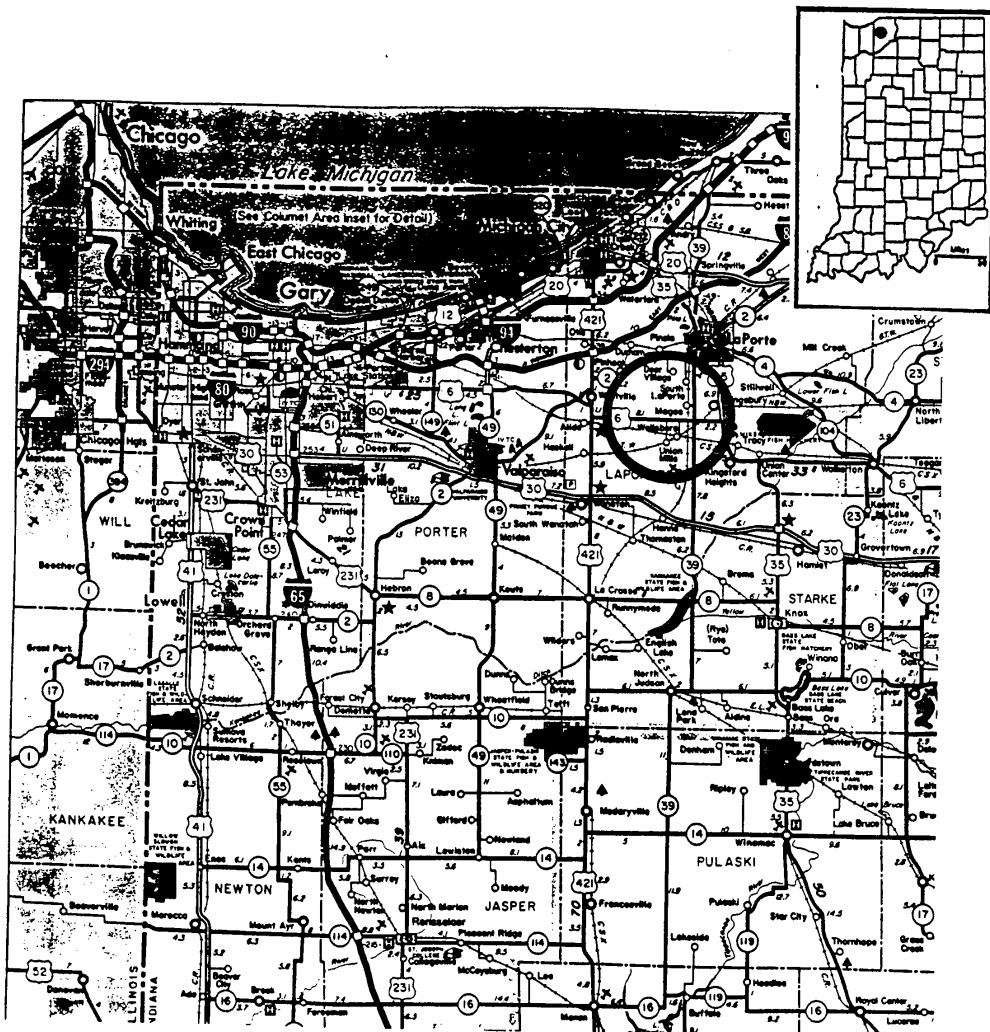
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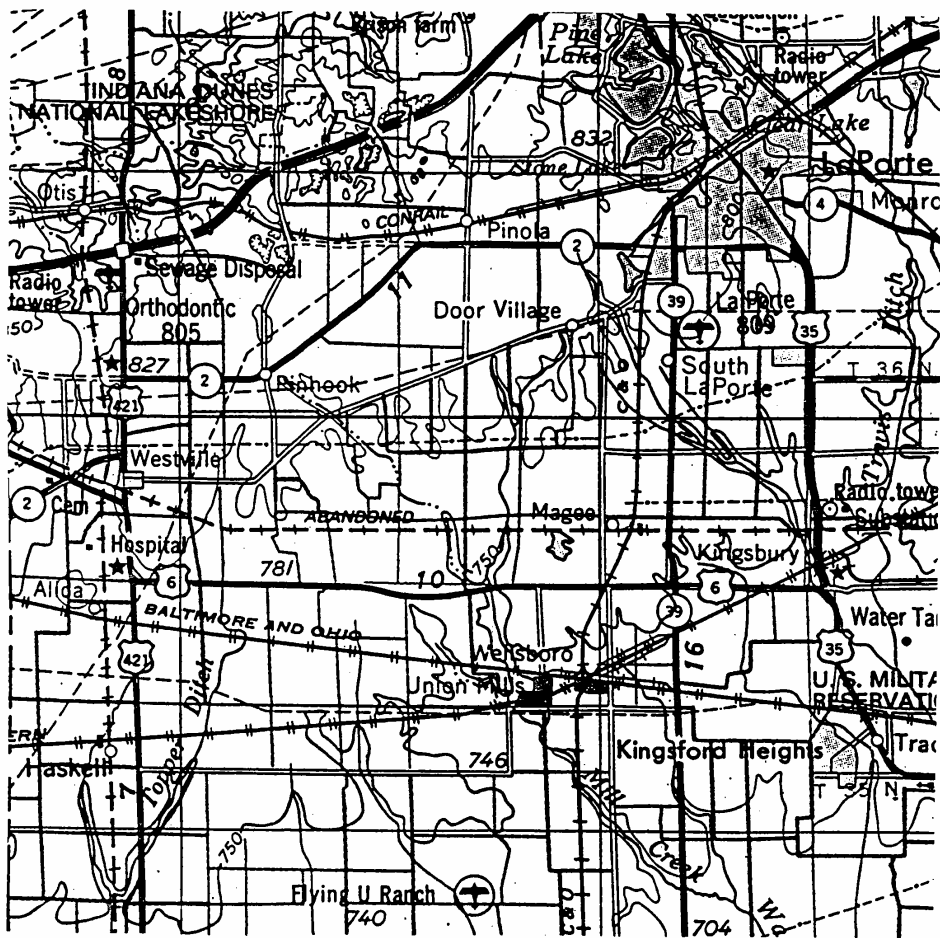
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Regional Location Map



Area Map



The Mill Pond as it appeared, late summer 1954.
(photo courtesy of Clayton Eaton)



The Mill Pond as it appeared, summer 1988.
(photo courtesy of Clayton Eaton)



The Mill Pond, view towards dam (April, 1989).
photo ESI



The Mill Pond, view towards dam (June, 1989).
photo ESI

Executive Summary

EXECUTIVE SUMMARY

Mill Pond is a eutrophic lake in LaPorte County, Indiana. Serious management problems have developed at the pond within the past ten years associated with nutrient loading from the watershed, infilling with stream delivered erosion products and excessive growth of aquatic weeds. The extent of these problems has expanded to the point that the pond has little recreational value.

The present study was designed to: 1) characterize current water quality, 2) determine the extent of basin infilling, 3) evaluate the feasibility of drawdown and dredging as management options, and 4) explore options for reducing nutrient and sediment loading to the pond through alteration in watershed management practices and wetland modification\construction.

Mill Pond is clearly eutrophic. The current wetland is trapping only 14-17% of the phosphorus delivered by Mill Creek largely because most creek flow is via a clearly defined channel and not through the fringing wetland. It is recommended that creek flow encouraged to sheet flow through the wetland, and a secondary dam should be constructed to affect this.

The pond proper has infilled to such an extent that approximately 64% of its surface area is characterized by water <2 feet deep. The sediments of the pond are loading phosphorus to the pond resulting in concentrations in the water column 17-60% higher than water entering via the creek. Our experiments indicate that lake drawdown and related sediment desiccation will not reduce sediment release of phosphorus and therefore should not be considered as a lake management option. Dredging appears to be the only feasible management tool for Mill Pond. Given that phosphorus concentrations did not vary significantly throughout core profiles, dredging to any depth will not alter sediment nutrient pools, but will improve fish habitat and likely reduce aquatic weed biomass during summer as a result of increased light limitation of growth. We found no evidence that disposal of dredged material would pose a serious contamination problem if deposited locally in fields.

Mill Pond 1.

CURRENT WATER QUALITY

Mill Pond was not included as part of the 1975 Indiana lake survey conducted by the Indiana State Board of Health, and no historical data were found in the files of the Indiana Department of Environmental Management, Indiana Department of Natural Resources, and the LaPorte County Health Department. It is most unfortunate that a historical data base does not exist for comparison with our 1989 data for delineating past trends in water quality.

Water quality data were collected three times during 1989: 23 March, 3 May, and 13 June. Parameters were measured at three stations on each sampling date (Figure 1). Site 1 (designated "Creek" on our diagrams) was located in the center of the Mill Creek channel approximately 150 m upstream from the old lime pit. Site 2 (designated "Pond" on our diagrams) was in Mill Pond proper immediately before the pond bends to the south to form the main pool. Site 2 (designated "Outlet" on our diagrams) was at the base of the dam where discharge from the pond was released. All analyses for chemical parameters were performed in state approved laboratories using current accepted United States Environmental Protection Agency methodologies.

The water column of Mill Pond failed to display any signs either temperature or oxygen stratification during summer 1989. Oxygen values tended to be above saturation throughout the water column due in large degree to the extreme photosynthesis of the extensive aquatic weed growth in the pond. It is likely, however, that some oxygen stress is exerted on fish populations at night when photosynthesis is no longer operating.

Results of our water quality investigations are presented in Table 1. Flow in the creek decreased throughout spring and into summer, while that of the outlet was lowest during March (Figure 2). With the exception of March, flow from the outlet was slightly greater than measured in the creek. While the creek pH remained constant throughout the study, that of both the pond and outlet increased progressively reflecting the seasonal expansion in weed populations during spring into summer with accompanying elevation in photosynthetic activity (Figure 3).

Two parameters, conductivity and alkalinity, were included in the present investigation in order to delineate the extent of cation and anion release from the watershed. Such parameters are useful for identifying the seasonality of watershed runoff and erosion. Conductivity (Figure 4) decreased throughout the study period concurrent with declining flow in the creek. An opposite pattern was displayed by alkalinity (Figure 5), a measure of the calcium

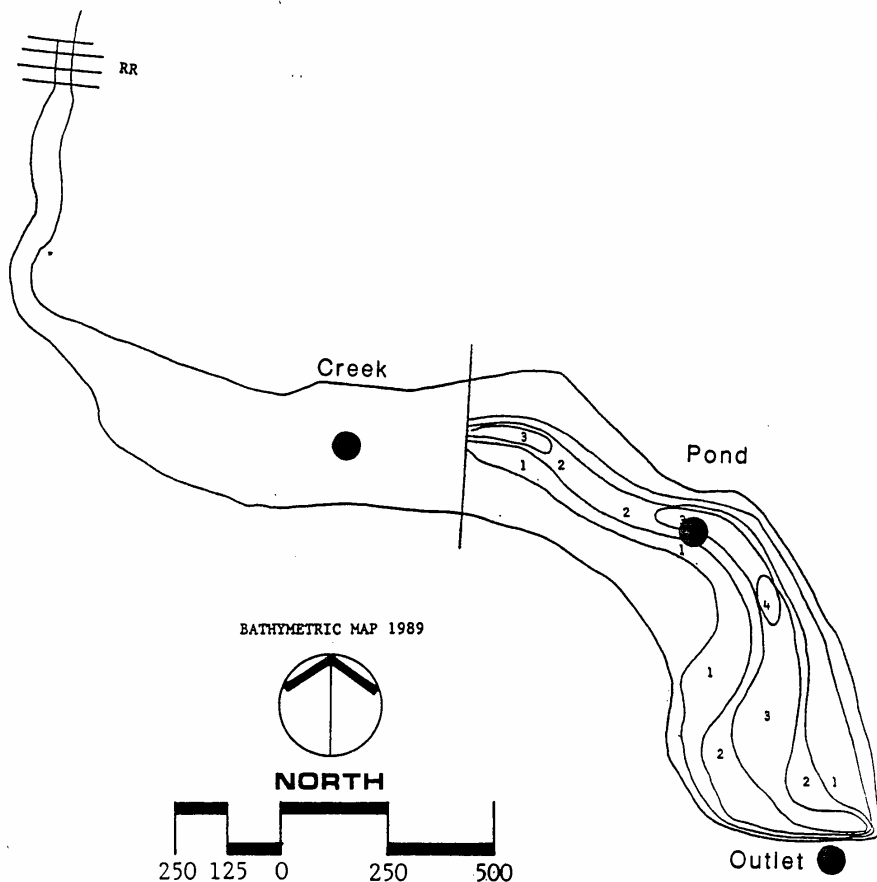
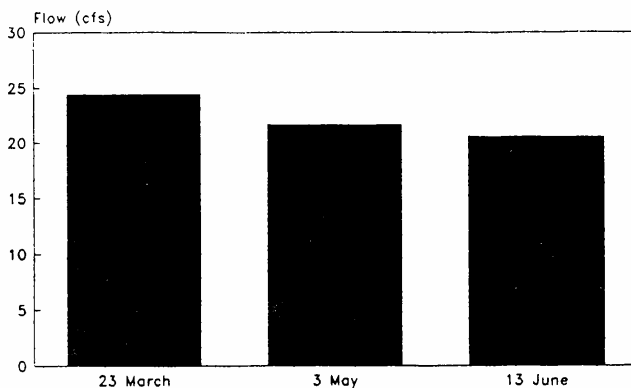


Figure 1. Water Quality Sampling Stations in Mill Pond for 1989.

Table 1. Physical and Chemical Parameters for the 1989 Survey of Mill Pond.

		23 March 1989			3 May 1989			13 June 1989		
		Creek	Pond	Outlet	Creek	Pond	Outlet	Creek	Pond	Outlet
Flow	cfs	24.41		6.66	21.68		29.66	20.58		27.14
pH		7	6.3	6.6	6.9	6.4	7	7	7.2	7.1
Conductivity	umho/cm	800	975	1075	500	490	450	450	450	400
Alkalinity	mg/L	177	193	193	180	168	180	208	218	208
Total Phosphorus	mg/L	0.08	0.08	0.08	0.07	0.06	0.07	0.12	0.1	0.16
Nitrite-Nitrate	mg/L	7.08	3.46	3.69	5	6.1	7.8	0.6	0.7	0.7
Total Suspended Solids	ppm	4	2	4	1	6	4	3	3	6

Mill Pond, IN Creek



Mill Pond, IN Outlet

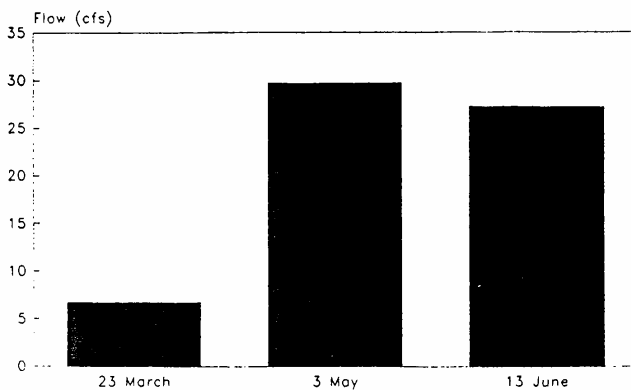
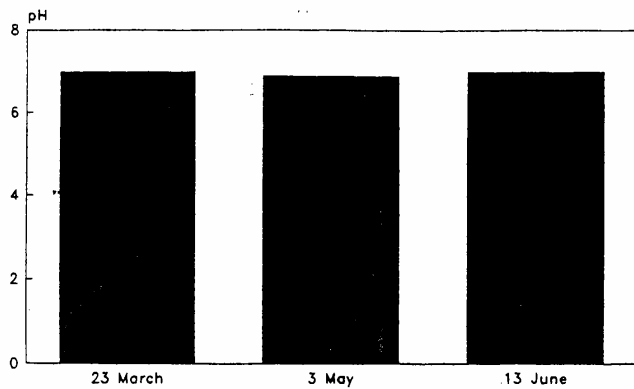


Figure 2. Flow at Individual Sampling Stations for Three Dates in 1989.

Mill Pond, IN Creek



Mill Pond, IN Pond

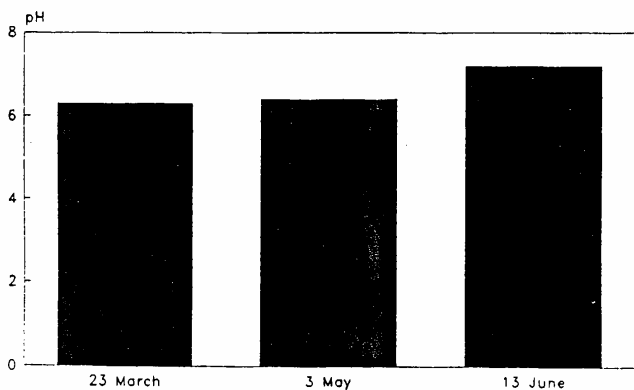


Figure 3. pH at Individual Sampling Stations for Three Dates in 1989.

Mill Pond, IN Outlet

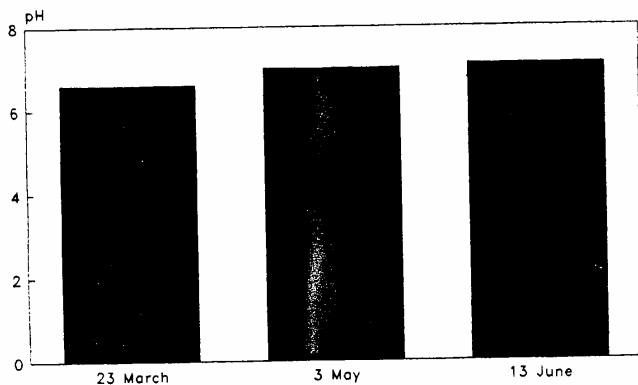
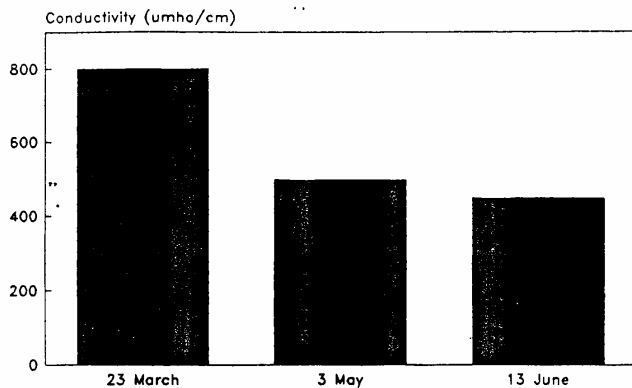


Figure 3. (Continued)

Mill Pond, IN Creek



Mill Pond, IN Pond

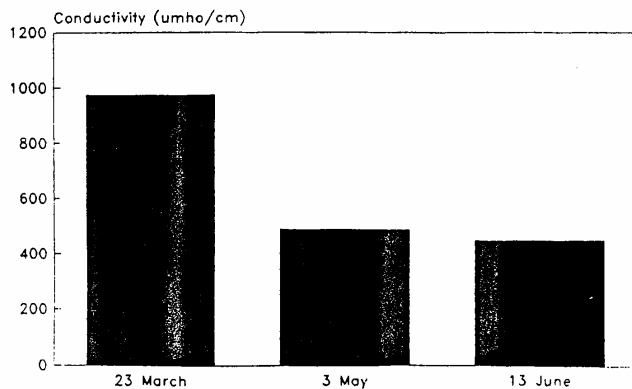


Figure 4. Conductivity at Individual Sampling Stations for Three Dates in 1989.

Mill Pond, IN Outlet

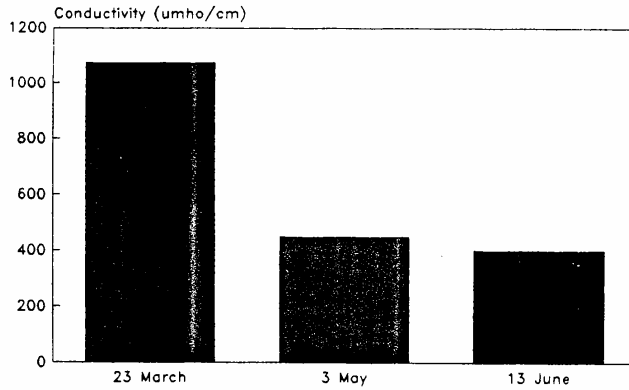
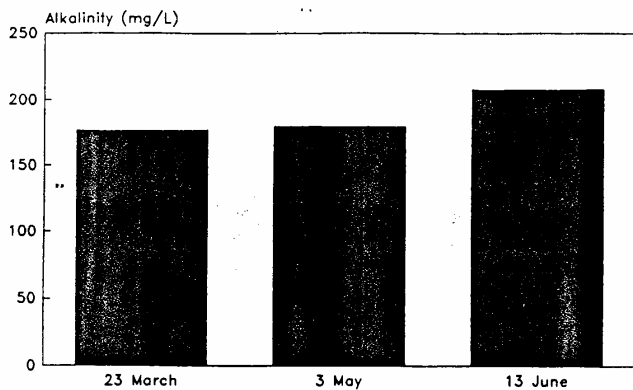


Figure 4. (Continued)

Mill Pond, IN Creek



Mill Pond, IN Pond

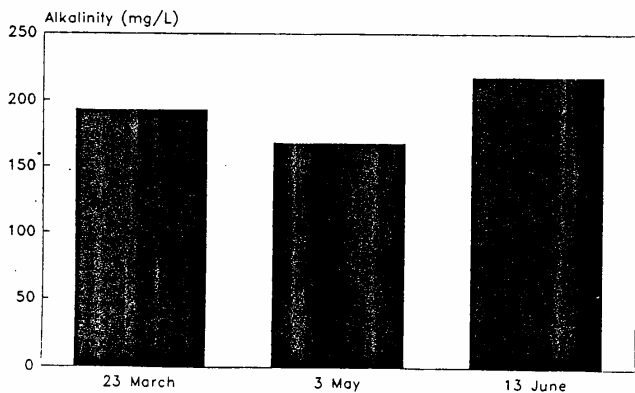


Figure 5. Alkalinity at Individual Sampling Stations for Three Dates in 1989.

Mill Pond, IN Outlet

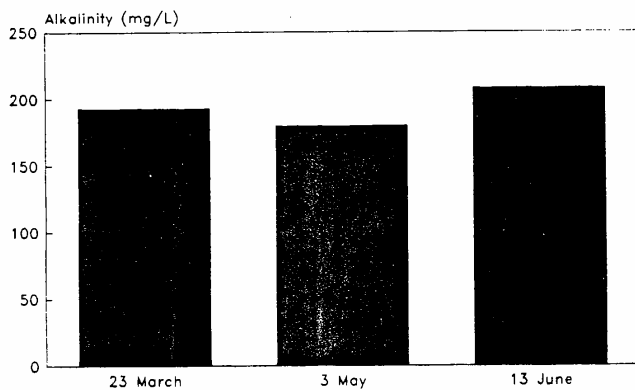


Figure 5. (Continued)

carbonate content of water. Such values of conductivity and alkalinity are characteristic of other eutrophic lakes in northern Indiana.

Phosphorus and nitrogen are the two nutrients most likely to be limiting weed and algal growth in lakes. It is generally accepted that increasing either of these parameters will stimulate plant photosynthesis and biomass thus promoting eutrophication. Total phosphorus values at all three stations declined between March and May then rose to maximum levels during June (Figure 6). Such a trend is commonly observed in Indiana and reflects runoff from fields during spring snow melt and rains during March, stabilization of watershed release during May via growing vegetation, and finally pulsed release of phosphorus reflecting fertilization of crops during late spring.

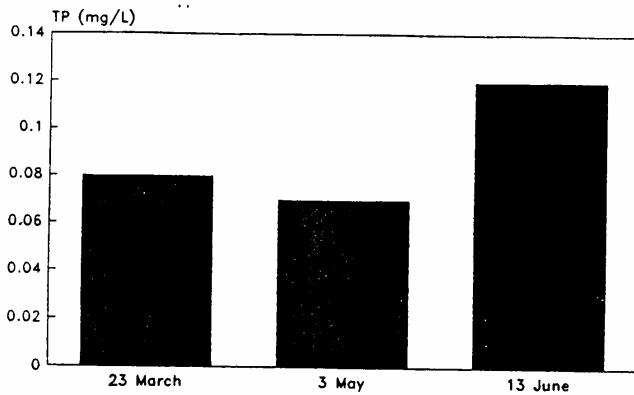
Phosphorus values in Mill Pond were within the range characterizing Class Three lakes (poorest water quality) of the Indiana Department of Environmental Management classification system. Such a classification system is based solely on water column phosphorus values and does not consider the extensive amounts of this nutrient tied up in aquatic weeds. Thus, in excessively weeded systems such as Mill Pond, using this classification system is a conservative estimate of actual water quality. Including the weed contribution in the total phosphorus pool would indicate even worse water quality. Mill Pond is clearly extremely eutrophic. Improper management of weed populations could even worsen current perceptions of water quality and increase the potential cost of system restoration.

Nitrogen has been reported as nitrite-nitrate (Figure 7). Unlike total phosphorus, nitrogen values were minimal during June. In general, values were characteristic of eutrophic lakes in northern Indiana. The final water quality parameter measured was total suspended solids (Figure 8). Values failed to display a pronounced seasonal pattern but in general were not considered elevated from values observed for other watersheds in northern Indiana.

WETLAND NUTRIENT RETENTION

This phase of the investigation was designed to determine whether the current wetland existing at the upstream end of Mill Pond is effective at trapping nutrients being delivered to the pond by Mill Creek. Such information was deemed important for devising a management plan for the pond. We were especially interested in determining how much of the current wetland should be retained as part of the

Mill Pond, IN Creek



Mill Pond, IN Pond

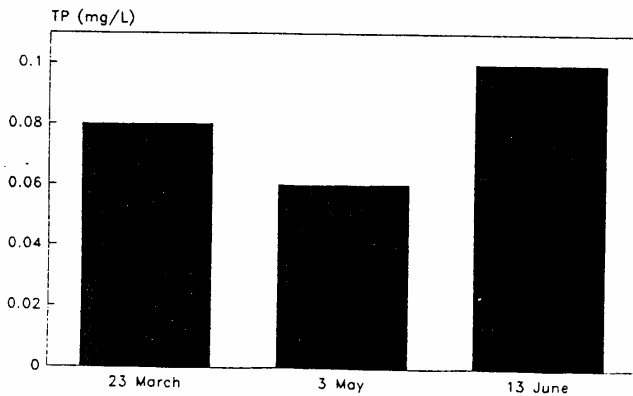


Figure 6. Total Phosphorus at Individual Sampling Stations for Three Dates in 1989.

Mill Pond, IN Outlet

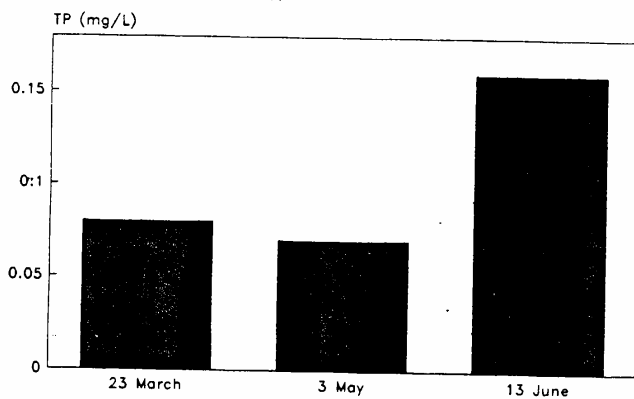
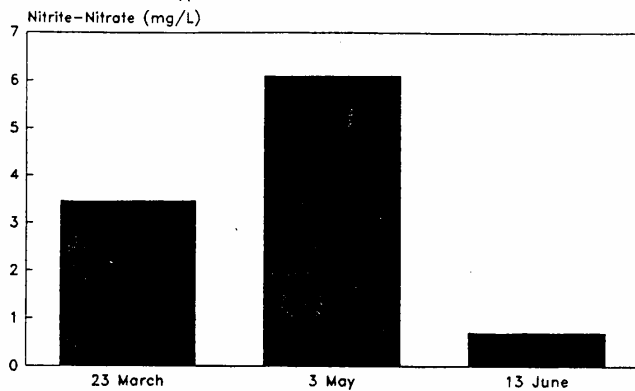


Figure 6. (Continued)

Mill Pond, IN Pond



Mill Pond, IN Creek

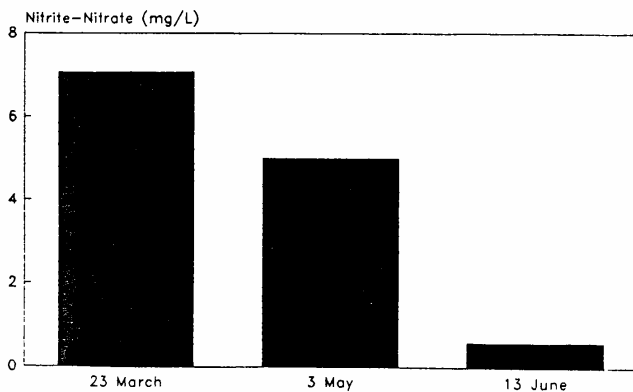


Figure 7. Nitrate-Nitrite Nitrogen at Individual Sampling Stations for Three Dates in 1989.

Mill Pond, IN Outlet

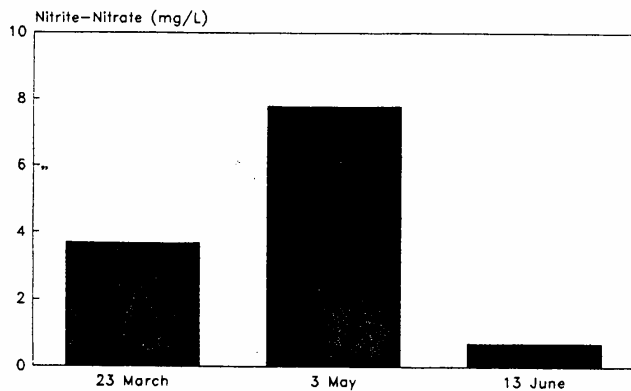
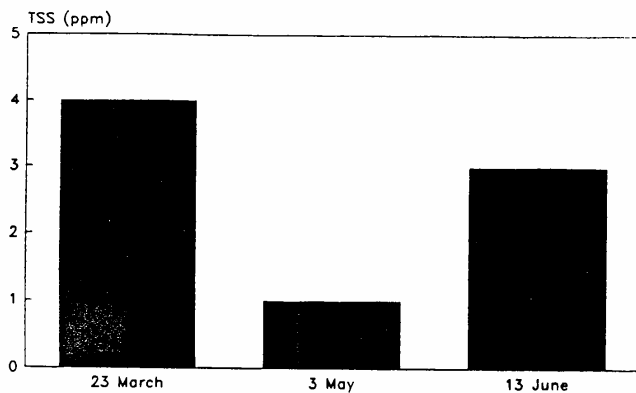


Figure 7. (Continued)

Mill Pond, IN Creek



Mill Pond, IN Pond

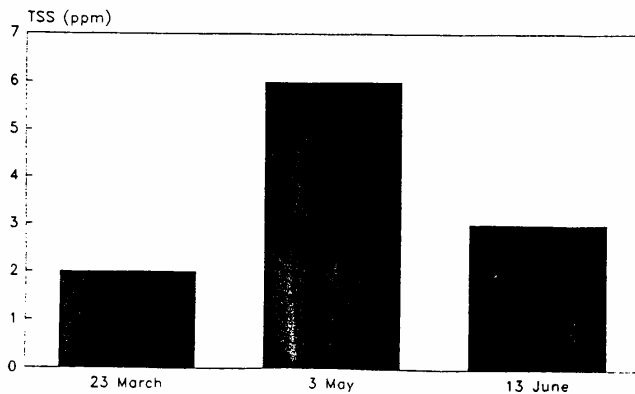


Figure 8. Total Suspended Solids at Individual Sampling Stations for Three Dates in 1989.

Mill Pond, IN Outlet

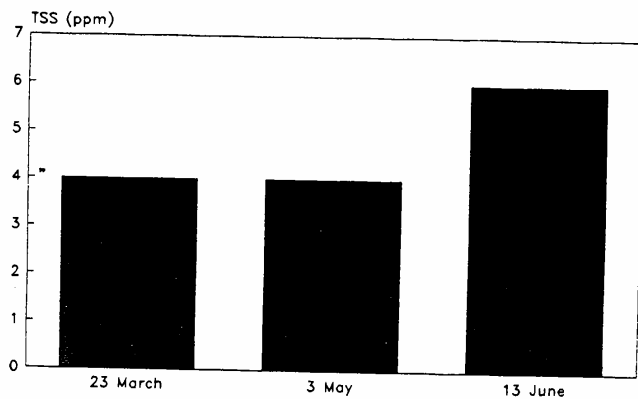


Figure 8. (Continued)

pond restoration plan and whether the relative effectiveness of the wetland for nutrient retention could be improved.

Outlet flow, with the exception of March, was generally greater than measured in Mill Creek at station 1 (Figure 9) suggesting that non-point drainage from the immediate watershed does contribute to the total water budget of the pond. Non-point discharge can be an important nutrient loader to lakes but is the most difficult to reduce as part of any lake management plan.

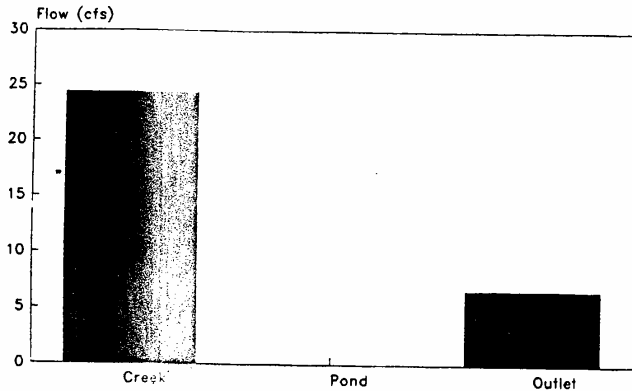
Pond pH values during both March and May were slightly lower than observed at the creek station, but water exiting the pond displayed a slight elevation in values over the initial pond station (Figure 10). Values for both pond and outlet during June were slightly greater than in the incoming stream suggesting that the great photosynthetic activity of the aquatic weeds in the pond elevates pH somewhat over background levels. Plant biomass during both March and May was not extensive enough to have a marked effect on pH.

Conductivity was greatest at all three stations during March 1989 and increased progressively from the creek to the outlet stations (Figure 11). This parameter decreased at all three stations from March through June as the aquatic plants were undergoing their normal seasonal growth expansion thus trapping cations and anions, components collectively measured as conductivity. Plant growth in Mill Pond was able to reduce conductivity in the stream by approximately 10% during the latter two months of the survey. Unlike conductivity, the buffering ability of the water (alkalinity) displayed little clear trend, and values for this parameter at the three stations for a given date were remarkably similar (Figure 12).

Total phosphorus concentrations were nearly identical at all three stations during March in large degree because aquatic and wetland vegetation was just beginning to grow and had not reached a sufficient biomass to be able to trap this essential nutrient (Figure 13). During May and June, however, the creek wetland was able to trap 14-17% of the phosphorus entering the pond via the creek. This figure is extremely low compared to literature values for properly functioning wetlands and is a direct reflection of the fact that a majority of creek flow is within the channel proper. While extensive, the wetland receives little of the creek water for removing nutrients.

While the wetland slightly reduces phosphorus concentrations in the creek, the pond, as evidenced by our data from May and June, functions as a net exporter of phosphorus downstream. Outlet total phosphorus concentrations during these two months were 17-60% greater

Mill Pond, IN
23 March 1989



Mill Pond, IN
3 May 1989

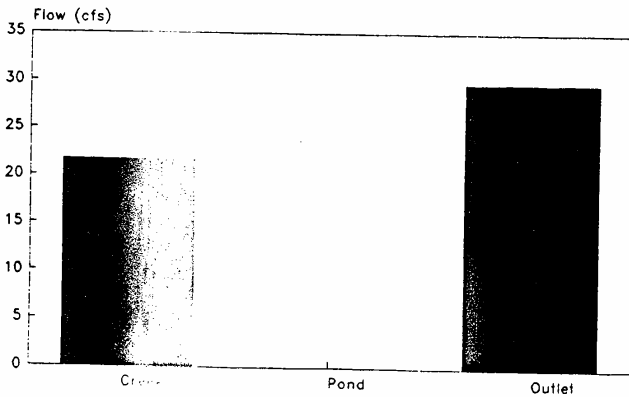


Figure 9. Comparison of Flow Among the Three Stations for Individual Sampling Dates of 1989.

Mill Pond, IN

13 June 1989

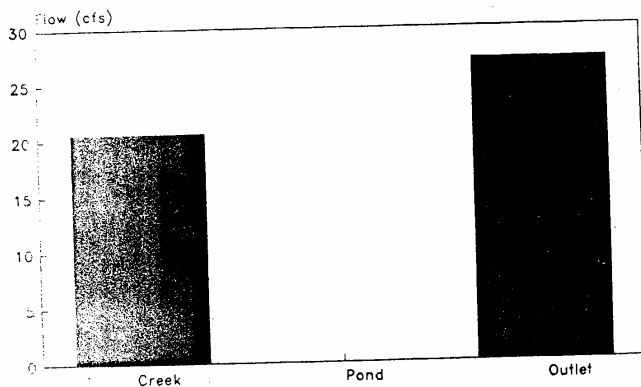
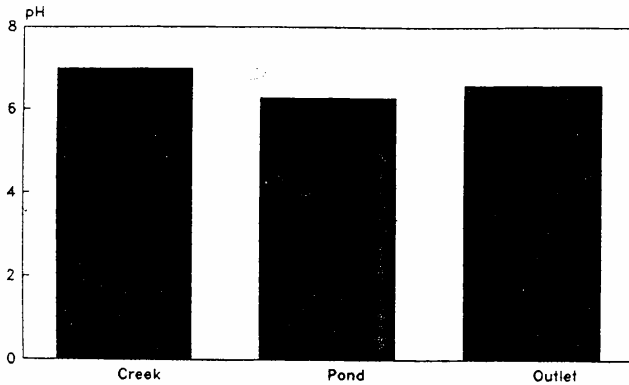


Figure 9. (Continued)

Mill Pond, IN
23 March 1989



Mill Pond, IN
3 May 1989

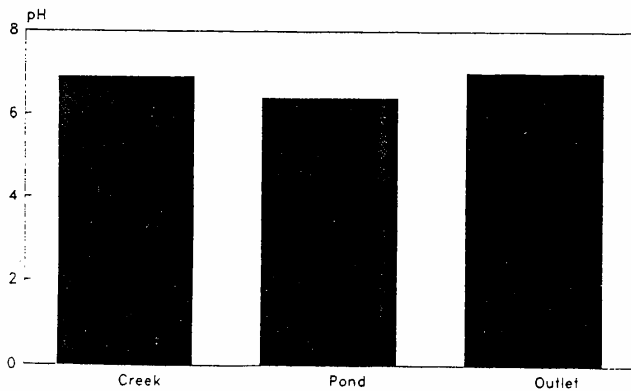


Figure 10. Comparison of pH Among the Three Stations for Individual Sampling Dates of 1989.

Mill Pond, IN
13 June 1989

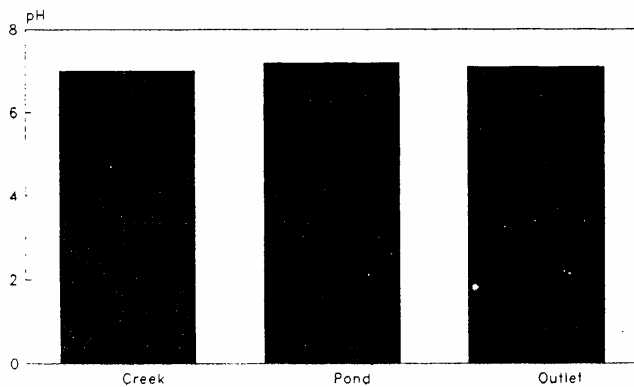
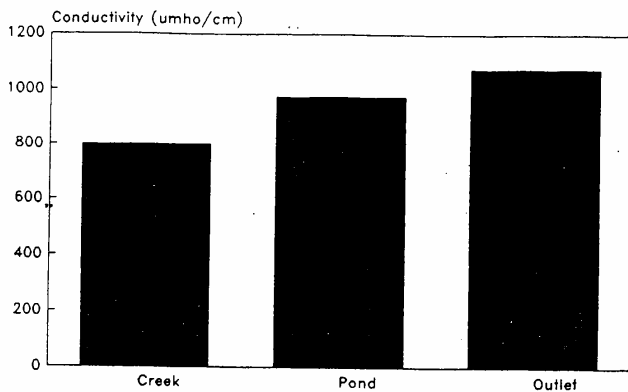


Figure 10. (Continued)

Mill Pond, IN
23 March 1989



Mill Pond, IN
3 May 1989

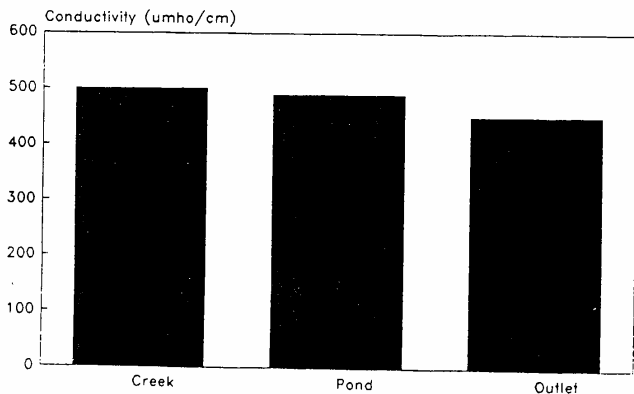


Figure 11. Comparison of Conductivity Among the Three Stations for Individual Sampling Dates of 1989.

Mill Pond, IN

13 June 1989

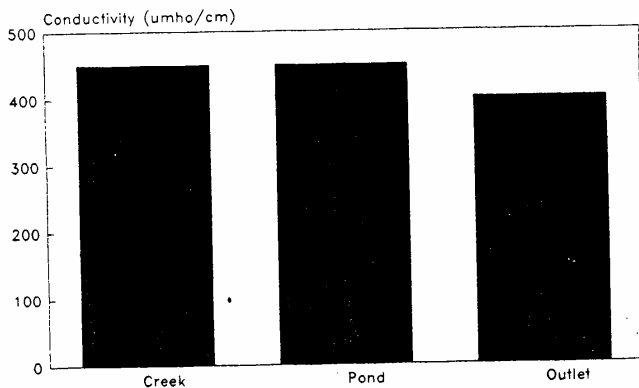
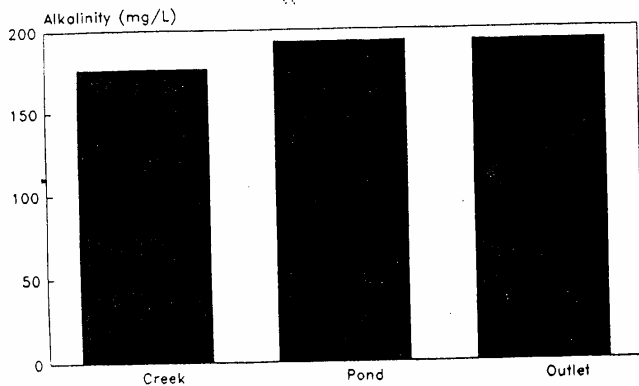


Figure 11. (Continued)

Mill Pond, IN
23 March 1989



Mill Pond, IN
3 May 1989

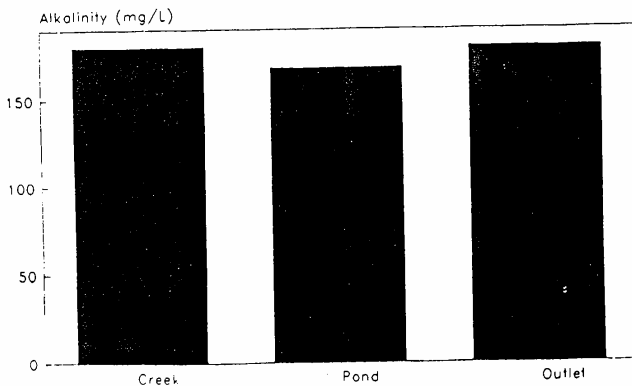


Figure 12. Comparison of Alkalinity Among the Three Stations for Individual Sampling Dates of 1989.

Mill Pond, IN

13 June 1989

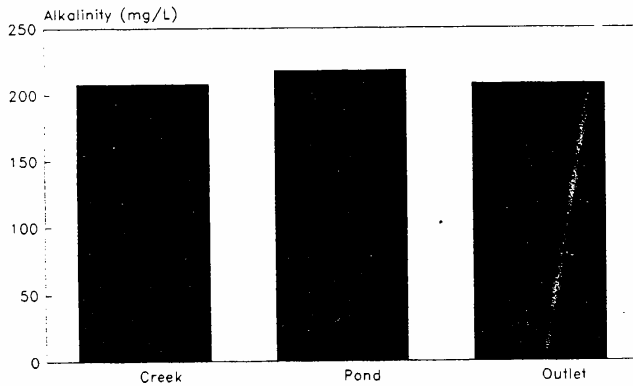
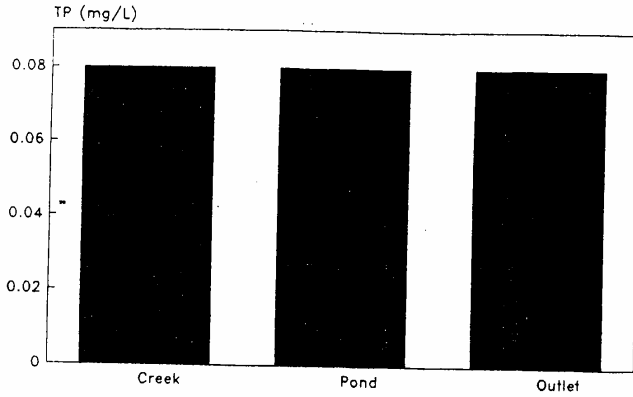


Figure 12. (Continued)

Mill Pond, IN
23 March 1989



Mill Pond, IN
3 May 1989

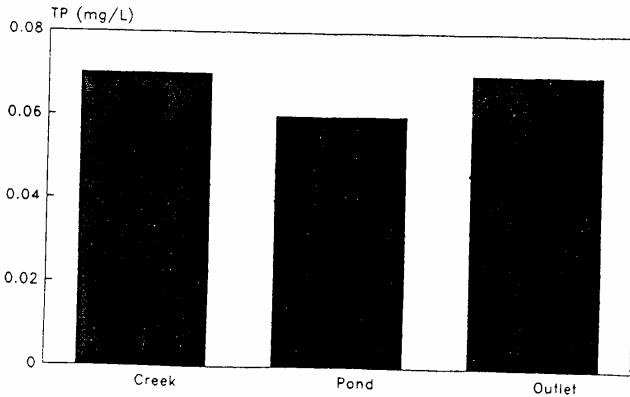


Figure 13. Comparison of Total Phosphorus Among the Three Stations for Individual Sampling Dates of 1989.

Mill Pond, IN

13 June 1989

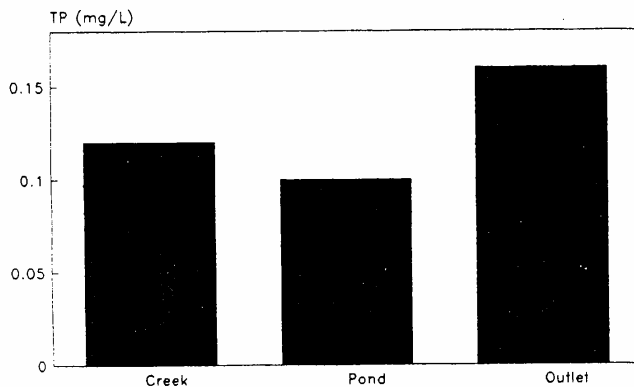


Figure 13. (Continued)

than found at the upstream pond station suggesting that the sediments of the pond are enriched in phosphorus delivered from the watershed via the creek and that such phosphorus is easily recycled.

Whereas the creek wetland was removing approximately 52% of the nitrogen being delivered by the creek to the pond in March, during both May and June the wetland actually released nitrogen to the pond, thus increasing creek values by 16-22% (Figure 14). As with phosphorus, the pond functions as a net exporter of nitrogen, again supporting the contention that sediments are enriched with watershed nitrogen that is in an easily recyclable form.

Total suspended solids (TSS) is a measure of organic and inorganic matter suspended in water. This parameter failed to display a clear trend (Figure 15). The wetland reduced TSS loading to the pond during March, increased it during May, and had no effect during June. Similarly, outlet TSS values were higher than the pond during March and June and lower during May. The increased export of TSS from the pond is attributed to algal blooms rather than release of inorganic sediment.

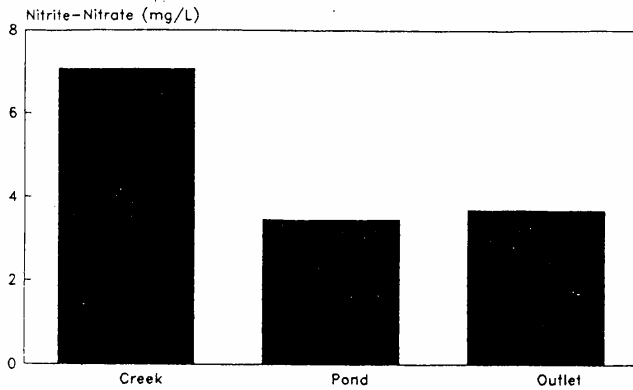
It is obvious that the current wetland is not functioning as an effective nutrient trap for Mill Pond. In large part this is a reflection of the fact that the creek follows a clearly defined broad channel through the wetland thus speeding delivery of nutrients to the pond without sufficient uptake by wetland plants. Due to pronounced silting, the wetland depth has been so reduced in recent years that water depth rarely exceeds one foot.

In order for the wetland to become an effective trap for Mill Pond, water flow must be spread out over the wetland rather than being confined principally to the creek channel. Construction of a secondary dam having a broad spillway at the wetland-pond boundary will increase both water depth in the marsh and the amount of time whereby wetland plants can uptake both nitrogen and phosphorus before creek water enters the pond. Although the wetland will gradually expand into the former creek channel, this should have no impact on watershed drainage requirements. Further details of our conceptual design for this wetland modification are presented later in this report.

BASIN INFILLING

A Raytheon recording fathometer was used to construct a bathymetric map for Mill Pond (Figure 16). Our mapping effort extended upstream to the point where the creek formed

Mill Pond, IN
23 March 1989



Mill Pond, IN
3 May 1989

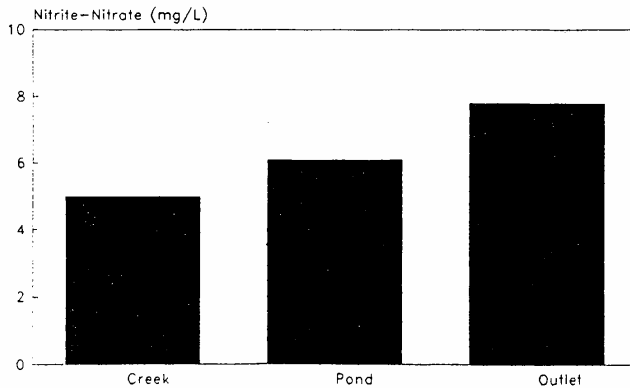


Figure 14. Comparison of Nitrate-Nitrite Nitrogen Among the Three Stations for Individual Sampling Dates of 1989.

Mill Pond, IN
13 June 1989

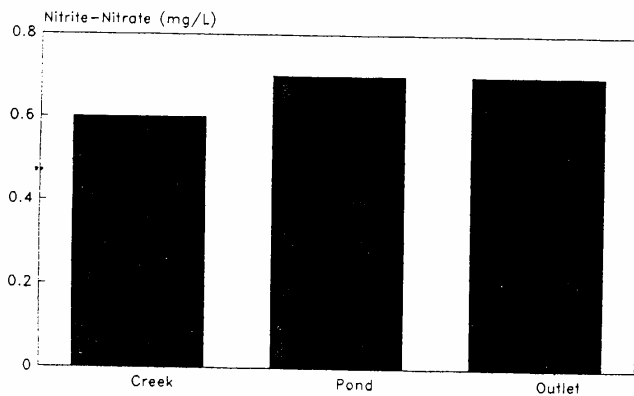
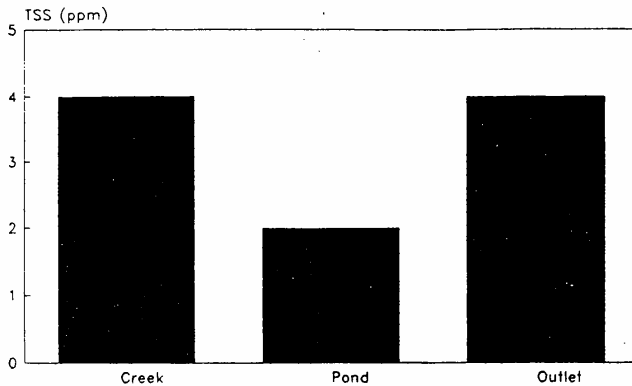


Figure 14. (Continued)

Mill Pond, IN
23 March 1989



Mill Pond, IN
3 May 1989

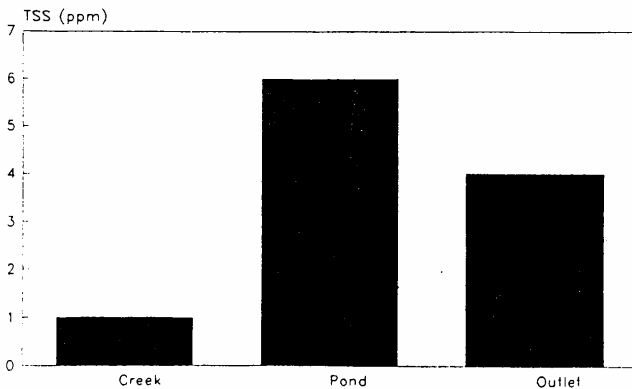


Figure 15. Comparison of Total Dissolved Solids Among the Three Stations for Individual Sampling Dates of 1989.

Mill Pond, IN
13 June 1989

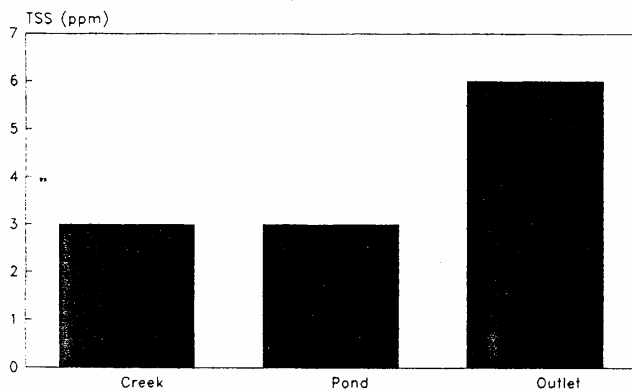


Figure 15. (Continued)

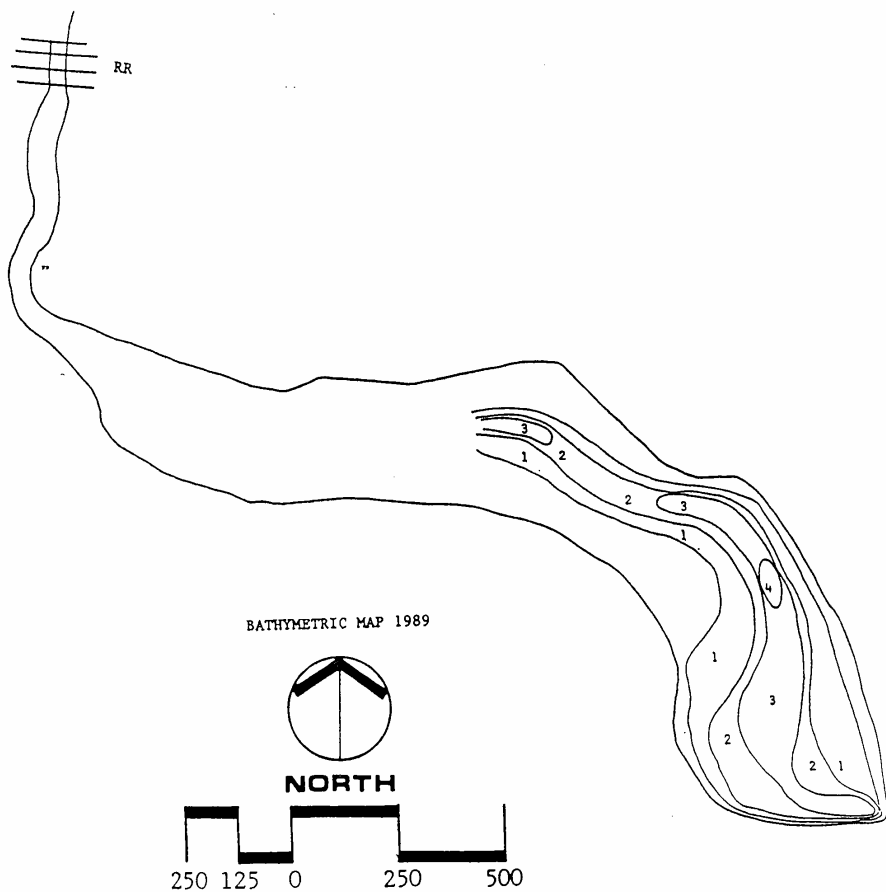


Figure 16. 1989 Bathymetric Map for Mill Pond.

a distinct channel through the wetland. It is clear that the creek has maintained a distinct channel through Mill Pond to the outlet structure. This channel is 3-4 feet deep and is clearly identifiable during summer as the last section of the lake to become completely weed choked.

The extent (acres) of each one-foot depth contour in Mill Pond is presented in Figure 17. Of the 10.3 acres mapped, 36% of the pond area was <1 foot deep, while an additional 28% was 1-2 feet deep. Thus, >64% of the pond surface area is too shallow to have any recreational value. By contrast, only 1% of the surface area of Mill Pond is >4 feet deep.

It is interesting to note that photos clearly demonstrate that Mill Pond was mostly open water during the summer of 1954 and free from weed growth. As will be discussed later in this report, the shift to the current weed problems may not be so much related to increased nutrient loading to the pond, but rather to extreme siltation that has so decreased pond depth that aquatic weeds can have sufficient light to become established and completely fill the water column with growth over most of the surface area of the pond. The effect of even small changes in depth on plant colonization and growth is readily apparent today, whereby the deepest sections (>3 feet) of Mill Pond are the last sections of the pond to become completely infested with weed biomass during summer.

LAKE DRAWDOWN

Drawdown is normally proposed in cases where sediments are extremely flocculent and thus easily release phosphorus into the overlying water of ponds. In reservoir systems such as Mill Pond, drawdown is easily accomplished by periodic short term modification of lake stage at the outlet structure whereby sediments over large sections or the whole lake are exposed to air drying. In practice, allowing sediments to dry removes pore water thus consolidating sediments and often forming a hard surface crust to the bottom. Upon reflooding, this hard crust may remain firm thus hindering physical mixing of sediments and associated recycling of phosphorus to promote algal and weed growth.

Our investigation was designed to simulate drawdown on undisturbed sediments from Mill Pond and to determine whether such action would reduce phosphorus release from the pond bottom. Sediment cores approximately one meter long were collected at five locations in Mill Pond by means of a piston coring device equipped with a clear plexiglass tube (Figure 18). Special care was taken to insure that the

Mill Pond, IN - 1989 Map
Area of Lake Bottom by Depth

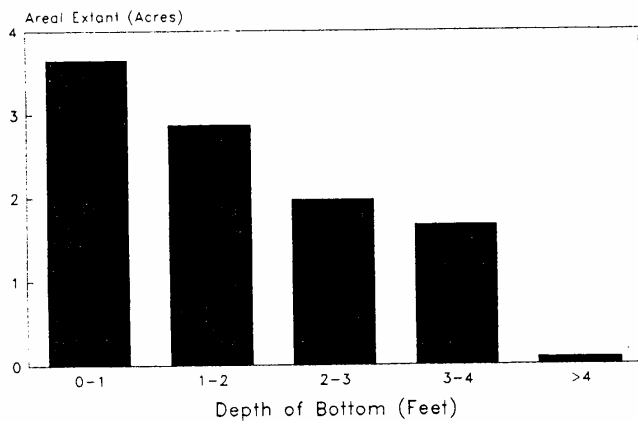


Figure 17. Aerial Extent of Individual One-Foot Depth Contours of Mill Pond for 1989.

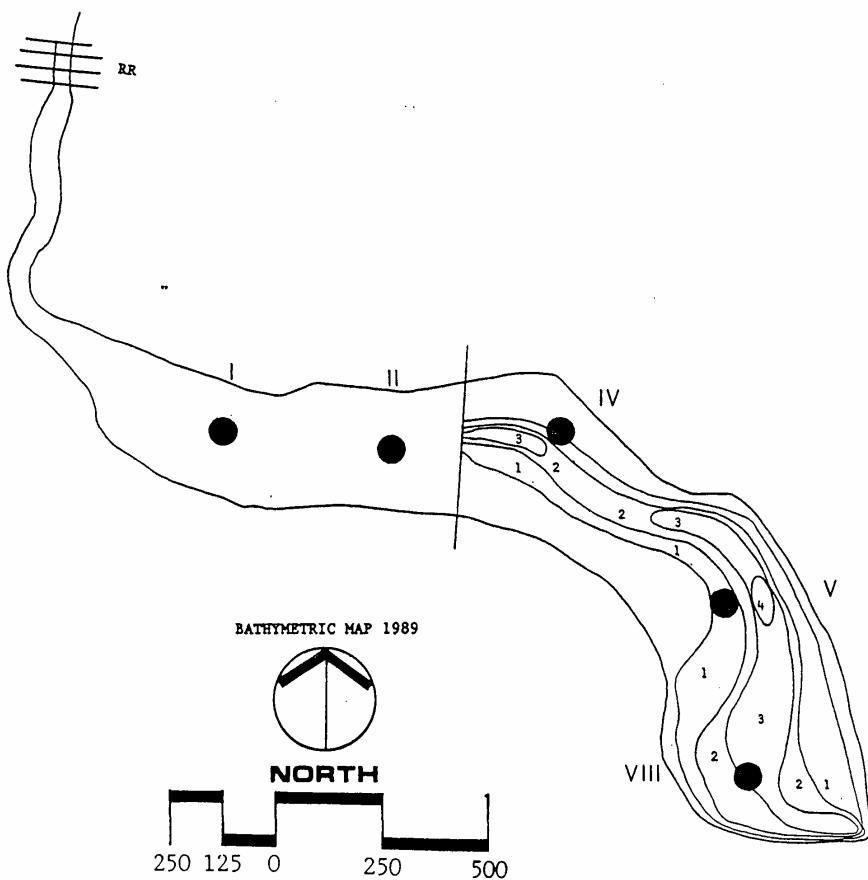


Figure 18. Locations of Sediment Cores Used for Drawdown Experiments.

sediment-water interface was preserved intact for each core. The cores were transported upright to the laboratory, where the overlying water was drawn off and the sediment surface allowed to dry out thoroughly. After complete desiccation, distilled water was added to the core tubes to simulate reflooding. The same volume of water was added to all cores. After two weeks, samples of overlying water from each core were collected and analyzed for total phosphorus concentration. A sample of the same distilled water used for the experiment was also analyzed for total phosphorus to serve as a control situation. The results of core phosphorus release following subtraction of the control are provided in Figure 19.

Total phosphorus release from reflooded cores ranged from .10 mg/L to .37 mg/L. The lowest release was from the core taken at the center of the pond basin and the highest was from the core taken farthest upstream in the wetland. We observed in the field that the sediments being deposited in the upper wetland were extremely "soupy" suggesting ease of phosphorus recycling. Sediments within the pond proper were more compact and thus more likely to retain phosphorus.

Earlier in this report we demonstrated that phosphorus concentrations at the outlet were 17-60% greater than found at the station located at the upper end of the pond. It is obvious that the pond sediments are actively releasing phosphorus into the water column. The range of total phosphorus values obtained following reflooding following simulated drawdown (.10-.37 mg/L) exceeds that of water entering the pond (.06-.10 mg/L) and supports our earlier contention that the sediments are an important source of phosphorus for the water column of the pond. Unfortunately, our results indicate that drawdown will do little to reduce the release of phosphorus from the sediments. Although easily implemented in reservoirs such as Mill Pond, drawdown has little value as a management tool.

DREDGING

Dredging can be used either to deepen lakes or to reduce sediment phosphorus recycling. If the latter is proposed, then the depth of sediment needed to be removed to significantly reduce sediment phosphorus concentrations and hence recycling ability must be calculated. Our investigation was designed to assess the feasibility of dredging as a management tool for Mill Pond using paleolimnological techniques. Sediment cores approximately one-half meter long were collected at three locations in Mill Pond by means of a piston coring device equipped with a clear plexiglass tube (Figure 20). Special care was taken to

Mill Pond, IN

Core Drawdown

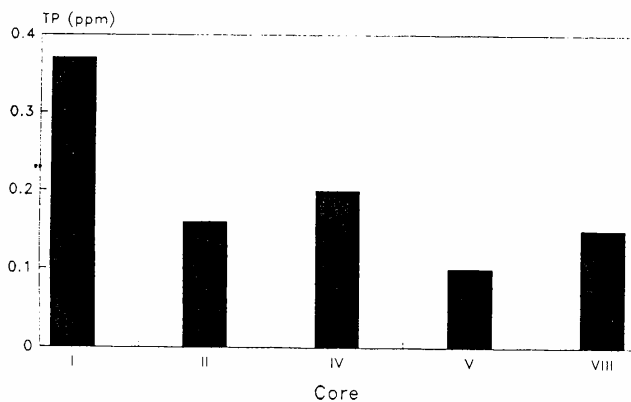


Figure 19. Total Phosphorus Release from Drawdown Cores Following Desiccation and Reflooding.

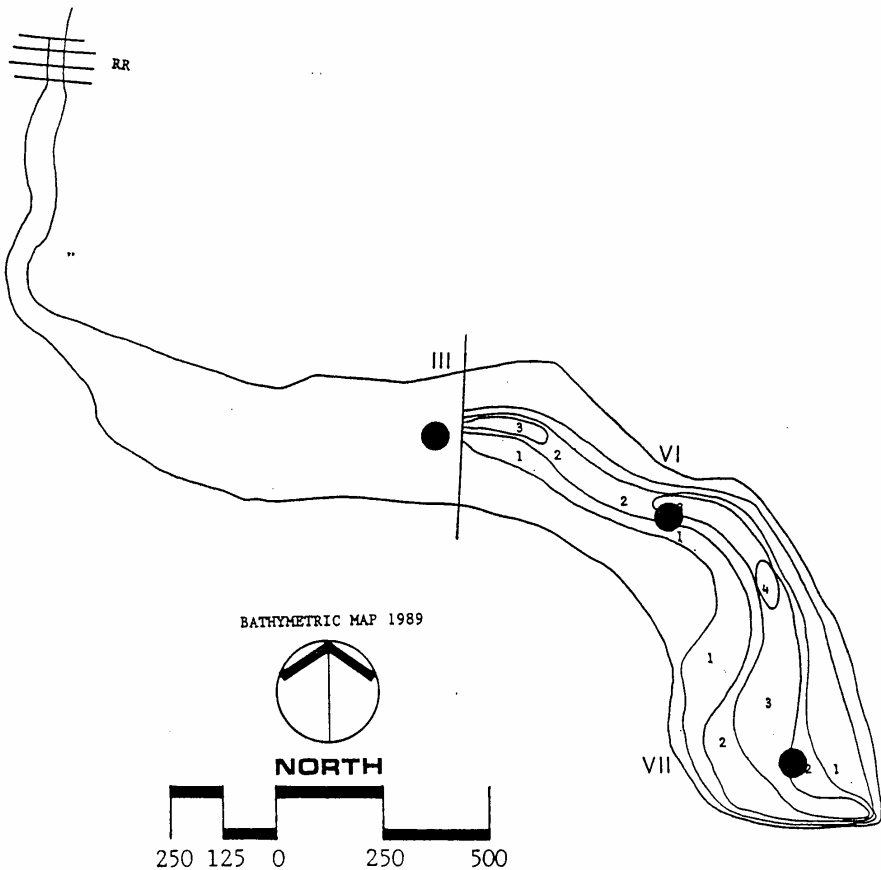


Figure 20. Locations of Sediment Cores Used for Physical and Chemical Profiles as Part of Dredging Study.

insure that the sediment-water interface was preserved intact for each core. The cores were transported upright to the laboratory where they were extruded within two hours of collection and sectioned at 1 cm intervals with each sample being placed in a plastic bag for storage. All samples were then kept at 4° C until analyzed.

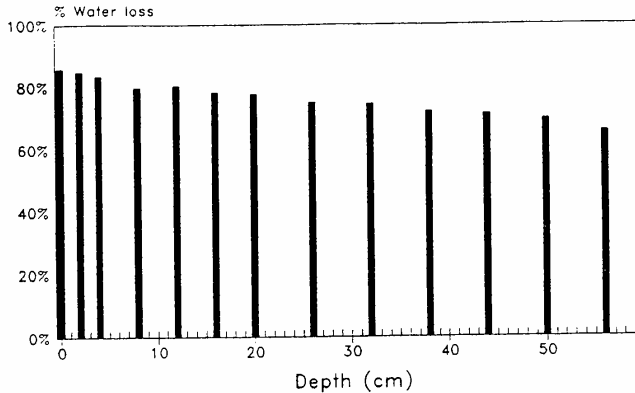
In addition to wet weight for select core levels, organic content was calculated as the difference in weight between the wet weight and that after drying at 100° C for 24 hrs. Inorganic content was calculated from the weight difference of the sample dried at 100° C for 24 hrs and ashed at 500° C for one hour. Phosphorus was determined by the standard ascorbic acid colorimetric method using filtrate collected from an HCl digestion of the sediment sample.

Water content of all three cores from Mill Pond remained above 70% throughout their entire lengths (Figure 21). The core (core III) collected from the most upstream site (the wetland) displayed both the least pronounced vertical variability and the greatest compaction of the most recently deposited sediments of any of the three cores. In general, the percentage of water in surficial sediments increased downstream. Such increased "soupiness" at the surface of cores is considered typical of eutrophic lakes.

Profiles of sediment inorganic content are presented in Figure 22. All three cores displayed reduced inorganic content in the upper 20 cm of their profiles. While this trend could reflect a reduction in the delivery of inorganic sediment to the pond either through effective watershed stabilization or a recent expansion of upstream wetland area in the past 30 years with an associated increased efficiency of trapping inorganic erosion products before they enter the pond proper, it is most likely the direct result of accelerated eutrophication. Under the latter scenario, the input of inorganic sediment could have remained constant through time, while the pond sediment has become increasingly organic from accumulating dead weeds. The trend towards consistently greater inorganic content in the profiles of downstream cores suggests that much of the silt laden water entering via the creek passes through the upper wetland reaches and deposits its sediment load mainly in quiet water areas of the pond proper.

It is indeed unusual to find such highly inorganic sediments in eutrophic lakes. Normally, one would expect >80% inorganic matter in either extremely unproductive lakes (oligotrophic) or reservoirs receiving heavy sediment loads from upstream. Such a finding at Mill Pond is a clear indication of the extent of watershed erosion and deposition of inorganic material in the pond and supports our earlier

Mill Pond Core # III



Mill Pond Core # VI

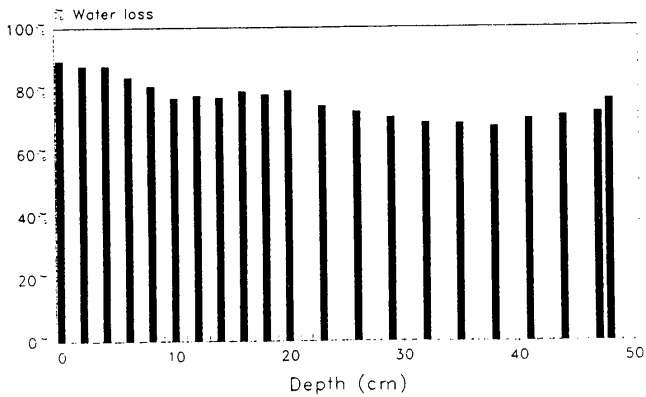
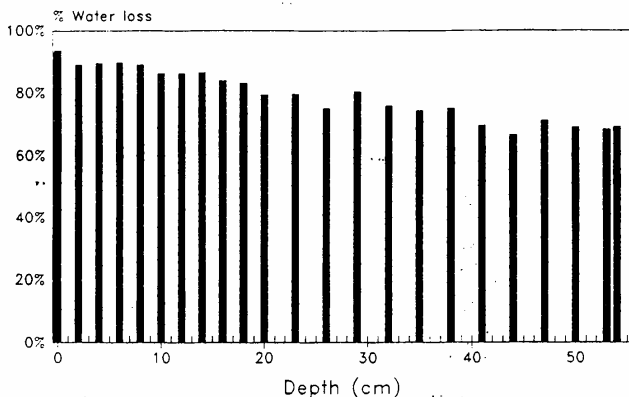


Figure 21. Profiles of Percent Water in Sediment Cores from Mill Pond.

Mill Pond Core # VII



Mill Pond, IN Core - Comparison

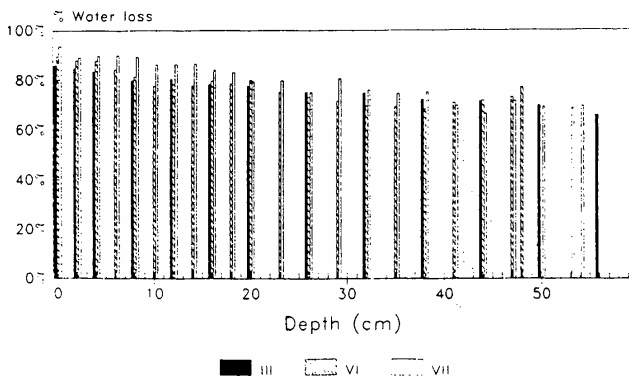
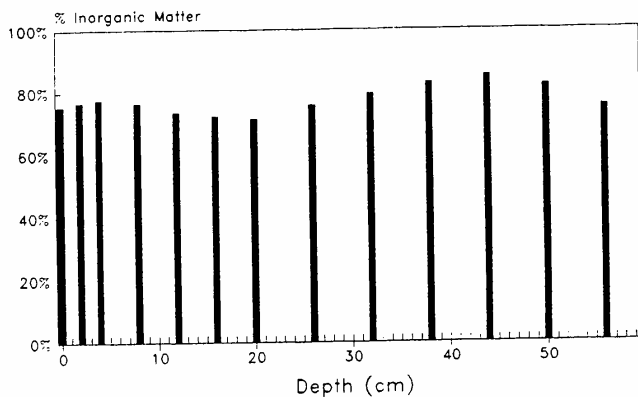


Figure 21. (Continued)

Mill Pond Core # III



Mill Pond Core # VI

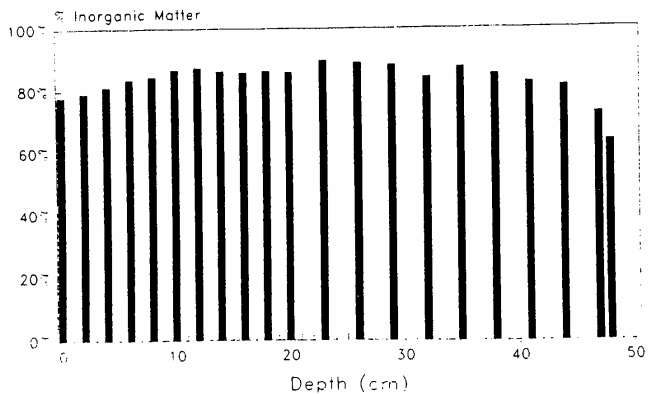
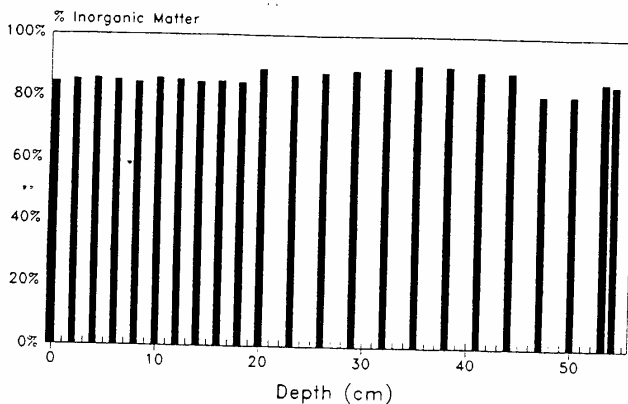


Figure 22. Profiles of Percent Inorganic Matter in Sediment Cores from Mill Pond.

Mill Pond Core # VII



Mill Pond, IN Core - Comparison

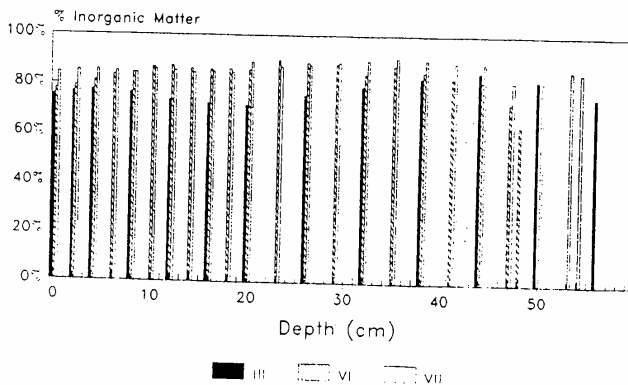


Figure 22. (Continued)

assertion that the volume of the lake has been reduced drastically in the past 30-40 years.

Profiles for sediment organic content were the mirror image of inorganic profiles in all three cores (Figure 23). Organic content rarely exceeded 25% of sediment dry weight and in general, decreased downstream in the Mill Pond system. All three cores displayed organic peaks at approximately 50 cm and 16-20 cm that are likely the result of temporary changes in the delivery of inorganic material to the pond system. As mentioned previously, such low organic content of sediment is not generally characteristic of so obviously eutrophic a pond as Mill Pond and is a direct reflection of the extremely high inorganic sediment load being deposited in the pond from the watershed. Although inorganic and organic percentages remained relatively unchanged throughout all three core profiles (Figure 24), it does not imply that the annual sedimentation of these parameters has remained constant for the past century.

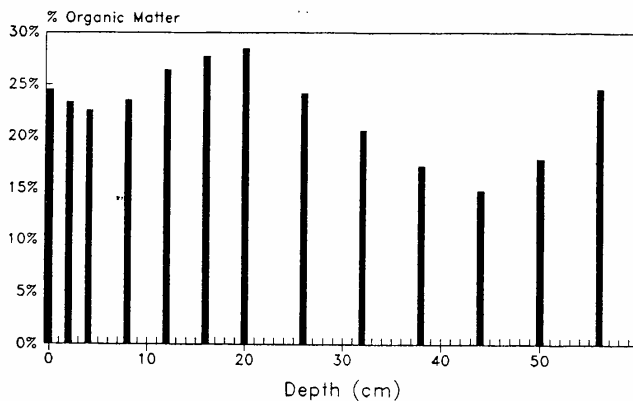
In situations such as Mill Pond where the percentage of inorganic and organic matter does not change appreciably along the length of a sediment core, it is conventional to express total phosphorus concentrations as a function of the total dry weight of sediment at a particular depth in the core. In this way, deviations in the total phosphorus to sediment dry weight ratio can be used to delineate periods of past phosphorus enrichment in the lake (Figure 25). Sediment total phosphorus concentrations decreased downstream in the Mill Pond system with the highest values found in the wetland and the lowest in the pond proper near the dam. Phosphorus values in wetland sediments were approximately three times greater than near the dam. Such a trend indicates that the wetland and upper pond act as a trap for phosphorus entering the pond. Unfortunately, phosphorus loading to the Mill Pond system from the creek exceeds the retentive capacity of the wetland thus allowing sufficient phosphorus to enter the pond proper to accelerate the eutrophication process.

The relationship between total phosphorus and sediment organic matter percentage for the Mill Pond cores is presented in Figure 26. The two parameters display similar trends along the length of the sediment cores suggesting that phosphorus is entering Mill Pond in a form that is easily utilized for algal and macrophyte growth.

Given the rather uniform core profiles of phosphorus from the three coring sites, dredging is not likely to reduce significantly phosphorus concentrations in the resulting upper sediment surface. There was no evidence for a zone of enrichment of phosphorus in surface sediments that

Mill Pond

Core # III



Mill Pond

Core # VI

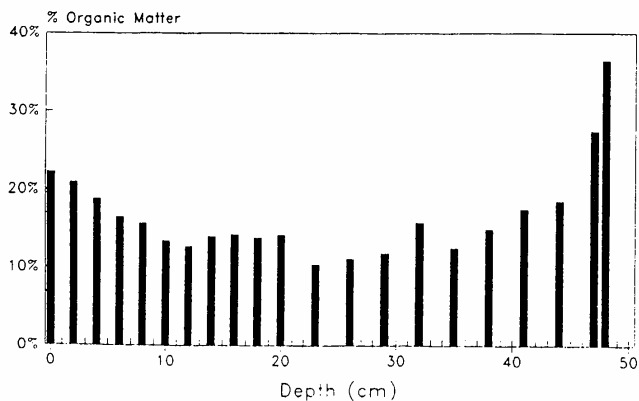
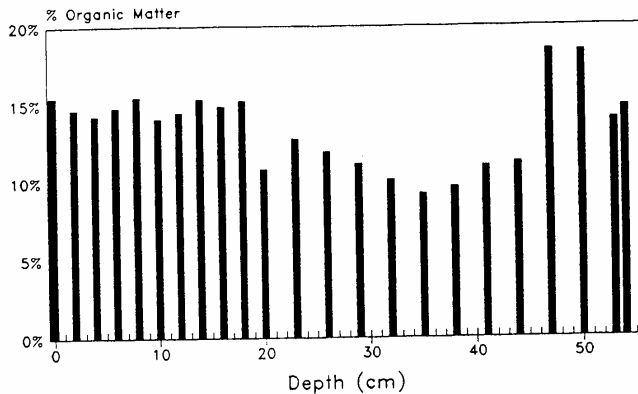


Figure 23. Profiles of Percent Organic Matter in Sediment Cores from Mill Pond.

Mill Pond Core # VII



Mill Pond, IN Core - Comparison

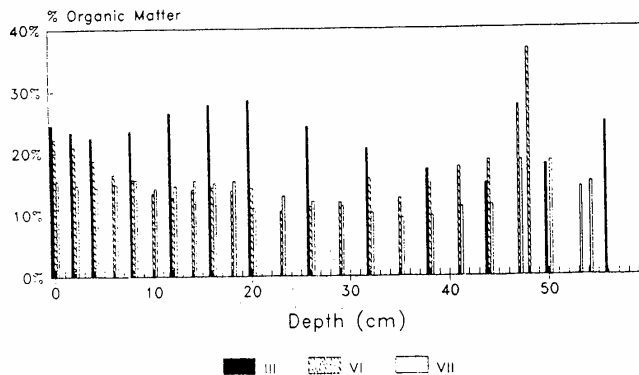
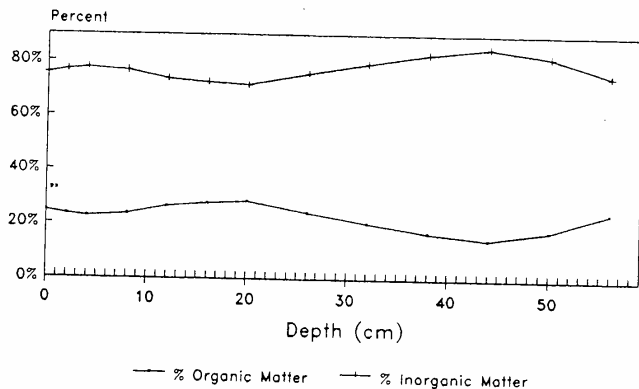


Figure 23. (Continued)

Mill Pond Core # III



Mill Pond Core # VI

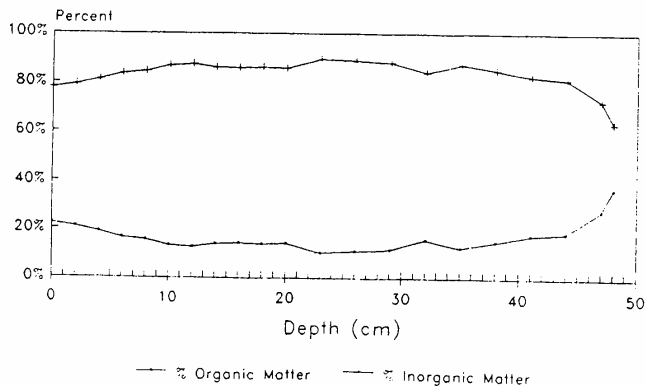


Figure 24. Comparison of Profiles of Inorganic and Organic Matter in Sediment Cores from Mill Pond.

Mill Pond Core # VII

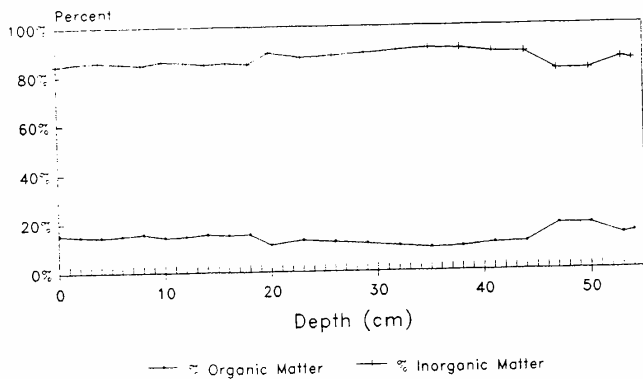
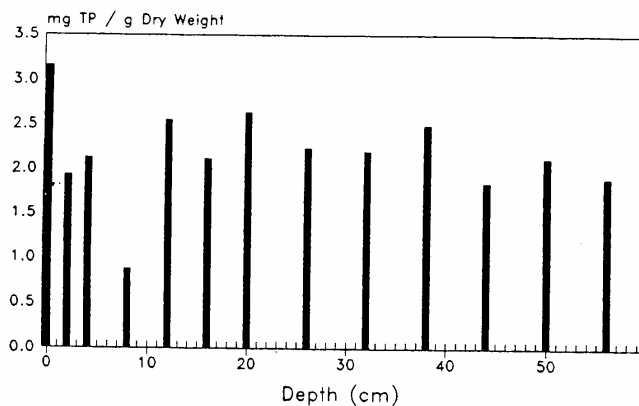


Figure 24. (Continued)

Mill Pond Core # III



Mill Pond Core # VI

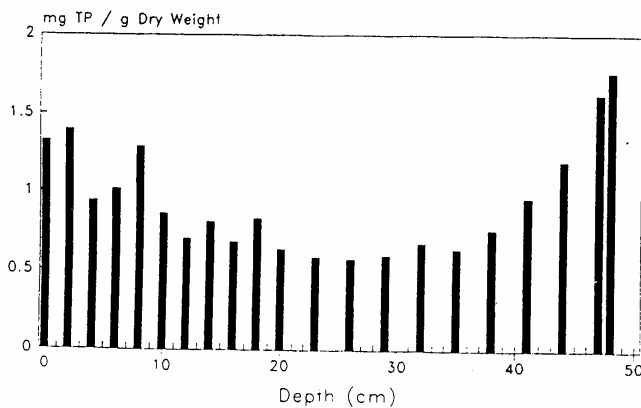
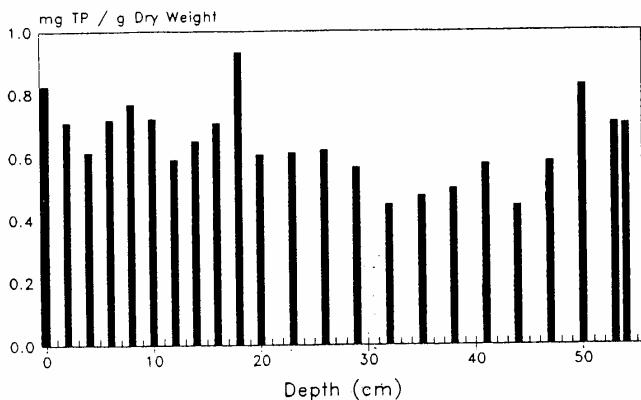


Figure 25. Profiles of Total Phosphorus Concentrations in Sediment Cores from Mill Pond.

Mill Pond Core # VII



Mill Pond, IN Core - Comparison

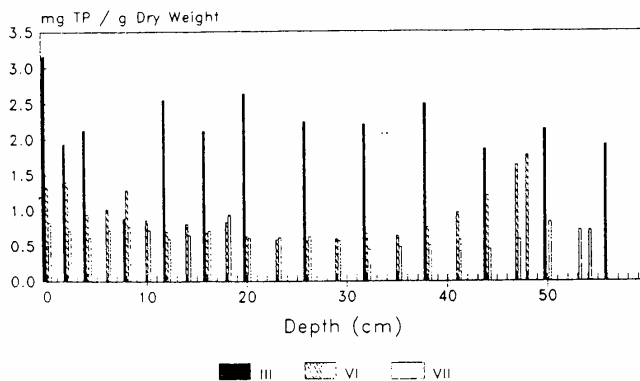
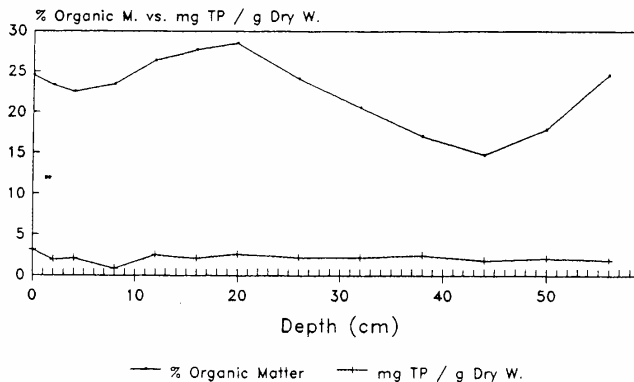


Figure 25. (Continued)

Mill Pond Core # III



Mill Pond Core # VI

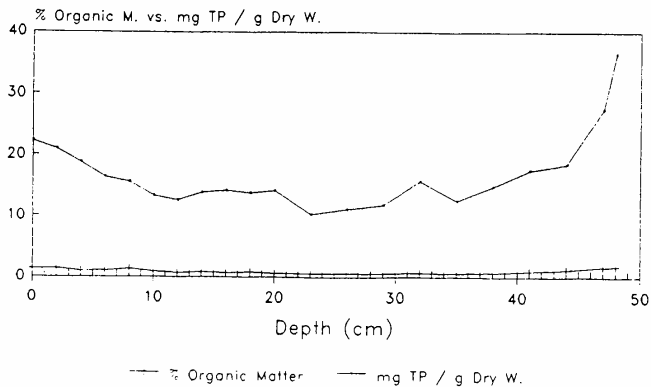


Figure 26. Comparison of Profiles of Organic Matter Percent and Total Phosphorus/Gram Sediment Dry Weight for Sediment Cores from Mill Pond.

Mill Pond Core # VII

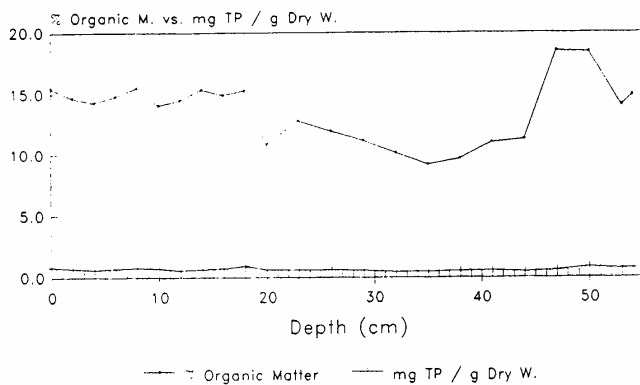


Figure 26. (Continued)

could be removed and thus reduce the potential recycling of this nutrient from the pond bottom.

When coupled with measures designed to reduce nutrient and sediment loading from the watershed, we consider dredging as a valuable management tool for Mill Pond. Although not likely to reduce phosphorus release from sediments, deepening of the pond via dredging will restore open water habitat for fish as well as limit the growth of weeds due to light limitation. The latter was seen even during 1989 whereby the deepest sections of the pond (>3-4 feet) remained weed free the longest during summer. Even a modest increase in lake depth to 10 feet should markedly reduce plant infestations. Our investigations at Lakes Bruce, Nyona and South Mud in Indiana have clearly demonstrated that weeds in even moderately eutrophic lakes do not cause management problems in water >10 feet deep.

If dredging is to be proposed as a pond management technique, it must be established that pond sediments are not contaminated with either metal or organic chemicals that, if not properly accounted for, could pose a pollution problem on the land disposal site. A total of 45 chemical parameters were measured on sediments collected from the middle of Mill Pond (Table 2). Aluminum, calcium, iron, magnesium and manganese concentrations were high but not uncharacteristic of ponds having extremely large watersheds. Neither these nor any heavy metal or organics were considered to pose a health or general pollution problem if sediments from the pond were to be disposed of on land.

Table 2. Concentrations of Metals and Organic Chemical
Contaminants in Surface Sediments of Mill Pond.

METALS	ug/g dry wgt	ORGANICS	ug/g dry wgt
% Solids	19.4	2,4,5-T	<0.7
Ag	<5	2,4,5-TP (Silvex)	<0.7
Al	11600	2,4-D	<0.7
Ba	193	2,4-DB	<0.7
Be	<2	B-BHC	<0.01
B	12	D-BHC	<0.01
Cd	5	Methoxychlor	<0.2
Ca	173000	Toxaphene	<0.2
Cr	13	4,4'-DDD	<0.02
Cu	12	4,4'-DDE	<0.02
Fe	22500	4,4'-DDT	<0.02
Pb	21	A-BHC	<0.01
Mg	4600	Aldrin	<0.01
Mn	2800	Chlordane	<0.02
Mo	22	Dieldrin	<0.01
Na	201	Endosulfan I	<0.02
Ni	15	Endosulfan II	<0.01
Sr	76	Endosulfan sulfate	<0.05
Ti	<5	Endrin aldehyde	<0.02
V	54	Endrin	<0.01
Zn	115	G-BHC (Lindane)	<0.01
		Heptachlor epoxide	<0.05
		Heptachlor	<0.01
		PCB's	<0.05

The Watershed 2.

The Watershed

The approach of this part of the study is to specifically address the effect of the off-site watershed on the Lakes. After preliminary study, the method was to target the area(s) of highest concern. Basically, our study had to start from the beginning to discover how this watershed was contributing to challenges in this lake system. The concerns to be identified in the watershed were as follows:

- a. Nutrient contribution to the Mill Pond;
- b. What are the probable sources;
- c. How much sediment is coming into the Mill Pond;
- d. How can sediment be reduced; and
- e. What are the intrinsic values of the watershed;
- f. How can the sources of sediment/nutrients be reduced from affecting the Mill Pond?

This feasibility study included the use of the following resources:

- a. Reconnaissance of the entire watershed by site visits on several occasions;
- b. Walking tours of some private property areas that could not be properly observed from public areas;
- c. Aerial photographs (County Surveyor);
- d. Aerial photographs (USDA - Soil Conservation Service, 1972);
- e. United States Geological Survey (USGS) map, Hanna Quadrangle;
- f. United States Fish and Wildlife Service, National Wetland Inventory map, Hanna Quadrangle;
- g. USDA - SCS Soil Survey of LaPorte County, Indiana, issued 1982;
- h. La Porte County records: Auditor, Surveyor, Treasurer, etc.;
- i. Various meetings and/or telephone conversations with State & County agencies, local property owners and;
- j. Engineering reconnaissance by ESI to determine suitability of potential target sites.

The main purpose of this investigation was to target the area(s) which would be the highest priority(ies) for land treatment systems for trapping nutrients and sediments in the watershed. These constructed solutions may consist of settling basins, constructed wetlands, sediment traps, or ponds, or shallow water habitat areas, etc. These terms are descriptive of similar broad-scale land treatment concepts that would reduce nutrient and sediment loading to the Mill Pond system. Other upland agricultural practices such as terracing, grassed waterways, conservation tillage, and animal waste disposal are all vital methods to improving the water quality of the lakes. These practices, however, are largely beyond the direct control of the Lake Association and are considered beyond the scope of this study. The goal of this feasibility study is to focus on the site(s) of greatest potential to most benefit the Mill Pond in the shortest time, and attempt to identify the process to create this system and its costs. The final considerations that would evaluate the feasibility and/or priority of such constructed projects would then be up to the Lake Association leadership. Discussions with the La Porte County Soil Conservation Service office indicated the awareness of problems with soils and agricultural practices above the Mill Pond. The SCS has pledged to help the Lake Association in any way possible including technical support, and initiating discussions with owners of properties which are contributing intolerable amounts of sediment, nutrient, and animal waste runoff. The SCS would be important support on constructed solutions, and could be of prime responsibility to encourage and/or design other land treatment practices.

Watershed impressions by visual survey

The purpose of this section is to express in narrative form the observations and general visual impressions that were made during site tours of the watershed and review of various aerial photographs. The intent is to provide a perspective that may be fresh and to stimulate residents to make their own continuing observations.

The scope of study for this report allowed for an overview of the watershed at a low level of detail. Many important features have been noted below and on the Watershed Summary Map (Figure 27). The Mill Pond itself is discussed elsewhere in the report.

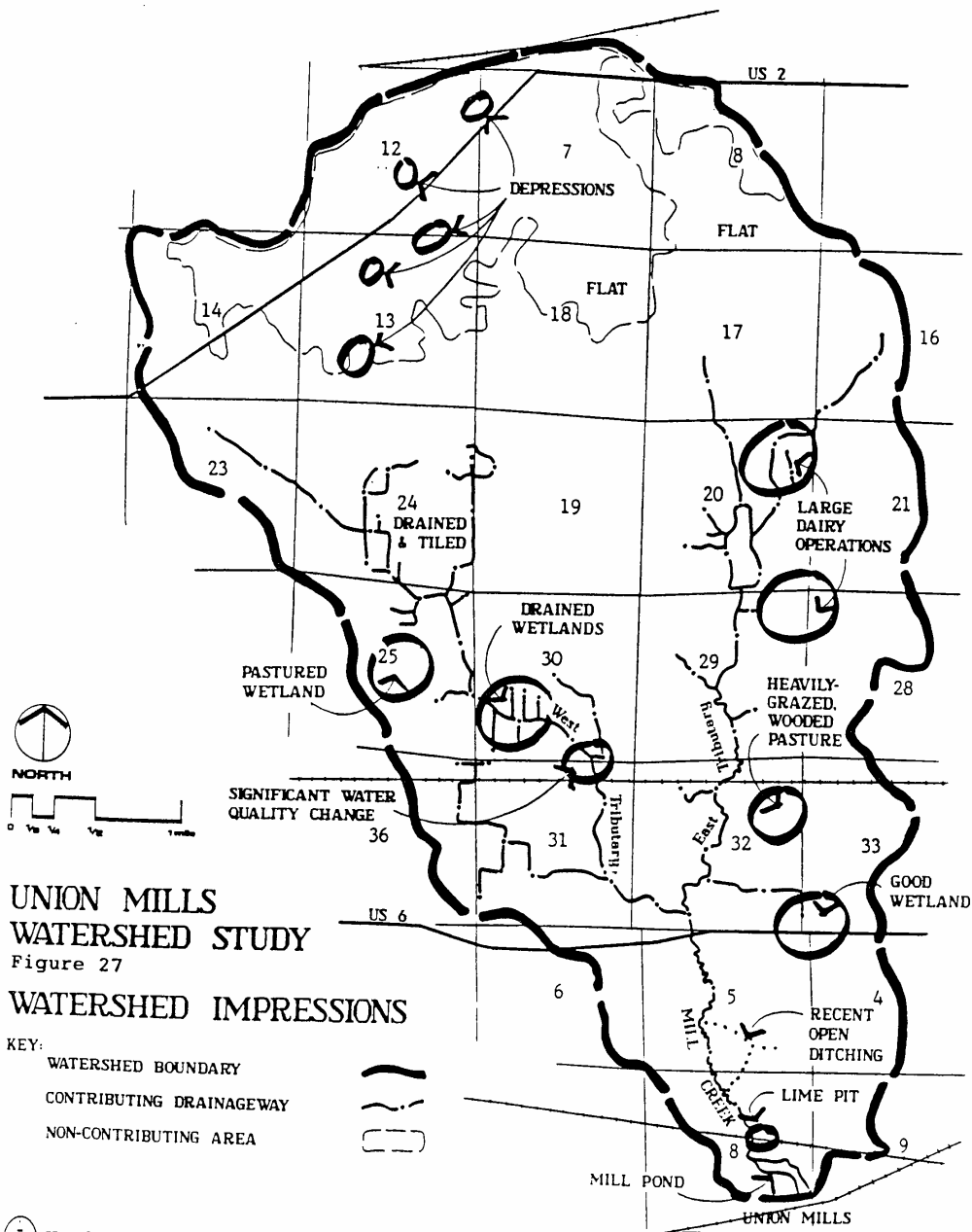
Items noted:

1. Only the northern portion of the town of Union Mills contributes drainage to the Mill Pond. Some of this runoff may be carrying lawn fertility, street runoff (salts), and septic system leachate.
2. Mill Creek is an outstanding, meandering natural stream for about two miles north of the Mill Pond.
3. The southern third of the watershed has a lot of topography which is critical because of its proximity to the Mill Pond.
4. Some recent open ditching in sections 5 and 8 has occurred. This has bypassed the natural filtering edge of the stream plain.
5. At the northeast side of the B & O railroad grade (section 8), an old lime pit remains. Less than an acre in size, some effect of this material is expected in the stream. But, also there is an opportunity here for some sediment trapping.
6. At the intersection of County Road 400W and U.S. 6 is a large, potentially 'good' wetland area. Part of it has been open ditched to Mill Creek which is about one mile to the west. The wetland area is partially effective now as a sediment nutrient trapping system. This area should receive individual detailed attention.
7. In the northeast corner of section 32 is a heavily grazed wooded area. Although somewhat buffered from Mill Creek, this "pasture" (high sediment and nutrient source) is only a quarter mile from the creek.
8. Continuing up the east tributary of the Mill Creek, two large dairy operations are noted. A cooperative effort of waste handling management should be planned.

9. The east tributary ends about six miles north of the Mill Pond in relatively flat uplands with several large depressions.
10. The sandy loam uplands are easily drained and excavated. Soluble nutrients are readily carried by ground water in these "open" types of soils.
11. The western tributary of Mill Creek begins in the southwest corner of section 32.
12. This tributary has been affected more by open ditching. Several very fertile sandy muck fields have been drained from former wetlands.
13. A significant water quality change was observed in the ditch where it crosses County Road 500S. This area needs stream sampling and monitoring to determine source. (We wish this had been within the scope of the study).
14. Another wetland area in section 25 is being pastured. This could be returned to wetland, but does not intercept a significant portion of the watershed.
15. Continuing northwest, more cropland has been drained and tilled.
16. Again, the upper reaches of this stream segment is characterized by flat to gently rolling land with some large depressions. These areas are considered non-contributing by surface drainage, but, again, ground water hydrology should be considered.

With these observations in mind, it seems critical that some nutrient/sediment trapping system be constructed immediately above the Mill Pond for some short term stabilization. Second, some of the land treatment practices be evaluated in detail, especially animal waste handling, pasturing, filter stripping, and tillage. It seems that this soil type would be ideally suited to no-till or mulch till farming. These methods of conservation tillage would also help retain fertility, as well as reduce erosion. Third, open ditching should be evaluated in detail. Abandonments may be possible, wetland restorations may be suggested, and certainly bank stabilization is warranted. Excavated sediment traps throughout the Mill Creek system may also be a part of the solution.

With these programs and management practices in place, improvements made in the Mill Pond proper will be more feasible and permanent.



Union Mills Land Use Study

In doing the land use study for Union Mills watershed area, aerial photographs were used from the 1982 La Porte County Soil Survey, published by the USDA Soil Conservation Service.

After each area photograph was joined to create the entire Union Mills watershed, a grid overlay was made to calculate map acreage into 10 acre parcels. Map scale was determined to be 1:15840 or 1" = 1320'.

The watershed was then divided into the following land use categories for tabulation and further calculation (table 3):

- Active Agriculture
- Forest
- Lake/Pond/Open Water
- Residential
- Wetland

Definition of each subdivision is as follows:

Agriculture: Those lands either planted or barren with the intended current or future use as crop production.

Residential: Lands occupied for private, personal use by either individuals or landowners.

Forested: Lands dominated by tree growth, excluding residential areas.

Wetlands: Marshes or depressional areas able to support hydrophytic vegetation throughout the growing season.

Open Water: Areas containing standing water throughout the year.

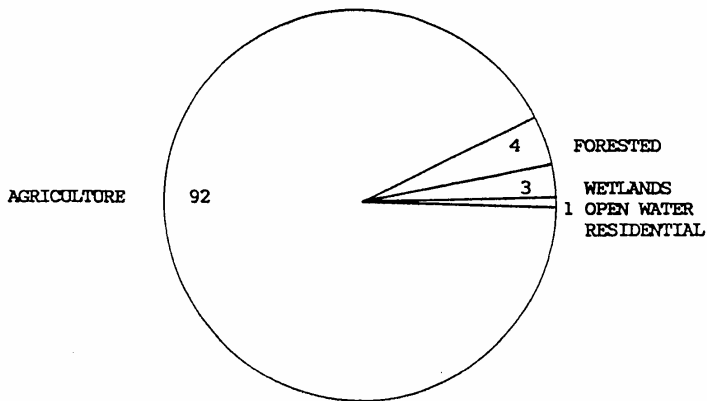
Results of the study are shown in the following pie diagram (Figure 28) and are calculated by percent of each category to the watershed as a whole.

Acreage for the entire Union Mills watershed was calculated from the USGS quadrangle maps using a planimeter and determined to be 13,823 acres.

WATERSHED CHARACTERISTICS

Drainage Basin Area (acres)	13,823.0	
Active Agriculture	12,662.0	(92%)
Forest	541.0	(04%)
Lake/Pond/Open Water	62.0	(<1%)
Residential	96.0	(<1%)
Wetland	462.0	(03%)
HEL	935.0	(07%)
Contributing HEL	693.0	(05%)
Basin Slope (m/km)	3.6	
Channel Slope (m/km): Mill Creek	1.9	
Precipitation (in/yr): Mean	42.4	
Standard Deviation	11.0	

Table 3. Characteristics of the Union Mills watershed.



UNION MILLS WATERSHED

LAND USE DISTRIBUTION BY PERCENT

(Figure 28)

Topography

The Union Mills watershed is characterized by the glacial outwash topography of the Kankakee Valley. The highest point in the Union Mills watershed is 850 feet above sea level, located 0.5 miles east of Durham. The lowest point in the watershed is 724 feet above sea level, located in the south end of Mill Pond. The average elevation in the Union Mills watershed is approximately 785 feet.

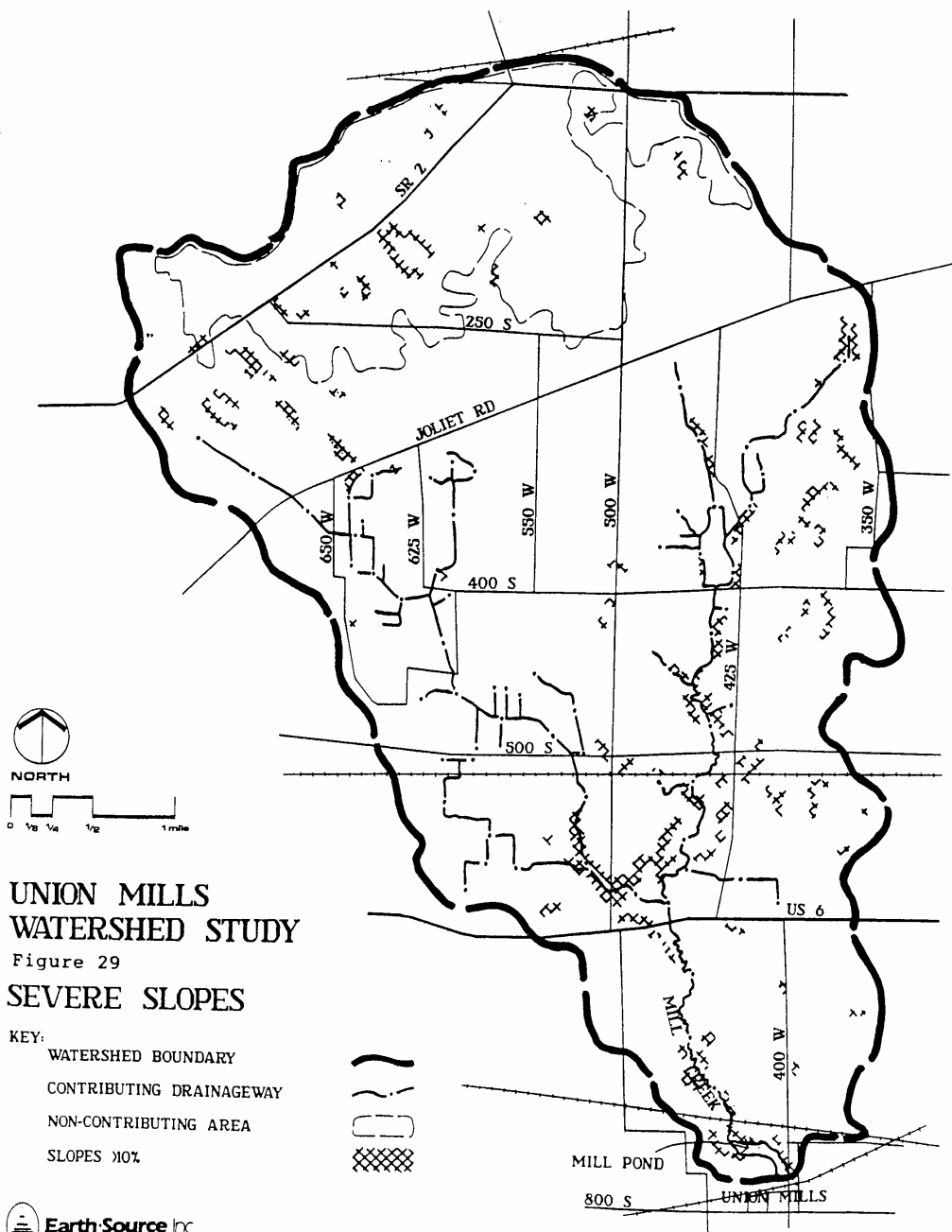
Relief throughout the watershed is greatly varied from nearly level (north), steeply sloping (central), to depressional in the south. Basin gradients in the Union Mills watershed range from 3.09 m/km in the north end of the watershed to 4.12 m/km in the south. The overall basin gradient is 3.60 m/km.

Severe Slopes

The length and steepness of slopes are major factors in assessing the probable erosion risks of an area. On steep or long slopes, runoff water accumulates in channels where increased flows produce greater erosive forces. Level or flat lands produce shallow overland flows over a larger area, this decreases the erosive forces of runoff.

The intent of this study-map (Figure 29) is to further illustrate the fabric of the land forms in the watershed. This study provides further evidence where the study emphasis should be. Some of the slopes indicated are in an area identified as having a "low contribution" of sediments. This graphic also substantially matches the worst conditions of Highly Erodible Lands.

In general, any area mapped as having severe slopes should not be in agricultural crop production or should be in a conservation tillage program. Some of these sloped areas are also too steep for development without special care, if at all.



Geology

The Union Mills watershed is underlain by bedrock of the Ellsworth Shale. The green shale was laid down in the Kinderhook Epoch of the Lower Mississippian Period (355 to 350 million years ago).

The Ellsworth Shale is covered by over 200 feet of unconsolidated glacial deposits. The most recent glaciation occurred some 12,000 years ago during the Wisconsin Advance. The Union Mills watershed is comprised of sediments deposited from the Lake Michigan Lobe of the Wisconsin Ice Sheet. This material is dominated by an outwash association of sand and gravel outwash-fan deposits. The glacial outwash-fan deposits display a southeast to south-southeast linear trend.

Soils

The soils of the Union Mills watershed (Table 4), are grouped in the Adrian-Houghton-Edwards Association and the Tracy-Chelsea Association (Figure 30) by the LaPorte County Soil Survey, 1982. The Adrian-Houghton-Edwards Association is characterized as nearly level areas with very poorly drained soils over sand and marl.

The Adrian soils are in the shallower part of the depressional areas or are near the edge of the deeper mucks. They cannot be differentiated from the other muck soils by sight. The organic layer is 16 to 51 inches thick. The surface soil is black muck over a very dark brown muck. Below this is sand.

The Houghton soils are in the deepest depressions or are in the deeper part of the depressional area. They cannot be differentiated from the other muck soils by sight. The organic layer is more than 51 inches thick. The surface layer is black muck over layers of very dark brown and very dark grayish brown muck.

The Edwards soils are also in the somewhat shallower part of depressional areas or are near the edge of units of deeper mucks. They cannot be differentiated from the other muck soils by sight. The organic layer is 16 to 51 inches thick. The surface layer is black muck over layers of black and very dark gray muck. Marl is below the organic layer.

The minor soils are the very poorly drained Martisco soils that have thin muck layers over marl; the very poorly drained Maumee soils that are sandy throughout; the very poorly drained Muskego soils that are muck over coroprogenous earth; and the very poorly drained Palms soils that are muck over loamy mineral materials.

The Tracy-Chelsea Association is characterized by level to very steep, well to excessively drained soils that formed in loamy and sandy outwash and eolian material.

The well drained Tracy soils are nearly level to very steep. They are on higher lying parts of outwash plains. They have a surface layer of dark brown sandy loam and a subsoil of dark brown sandy loam, loam, gravelly sandy clay loam, and gravelly sandy loam.

The excessively drained Chelsea soils are gently sloping to strongly sloping. They are in rolling sandy areas. They have a surface layer of very dark gray fine sand and a subsurface layer of dark brown, dark yellowish brown, and light yellowish brown fine sand. Below this is light yellowish brown fine sand that has thin bands of dark brown loamy sand.

The minor soils are the somewhat excessively drained Tyner soils and the well drained Elston soils that are nearly level or gently sloping; the moderately well drained Hanna soils that are nearly level and gently sloping and are in slightly lower parts of the landscape; the somewhat poorly drained Bourbon soils on the low lying, concave, broad flats; the poorly drained Quinn soils on low lying, broad flats; the very poorly drained Gilford and Washtenaw soils along poorly defined drainageways and in low lying pockets; and the ponded Histosols and Aquolls in bogs and swamps. (Source: LaPorte County Soil Survey).

Table 4. Soil Legend:

Map symbols consist of a combination of letters and numbers. The first capital letter is the initial one of the map unit name. The lowercase letter that follows separates map units having names that begin with the same letter, except that it does not separate sloping or eroded phases. The second capital letter indicates the class of slope. Symbols without a slope letter are for nearly level soils or miscellaneous areas. A final number of 2 indicates that the soil is eroded. (source: USDA, Soil Conservation Service)

SYMBOL	NAME
Ad	Adrian muck, drained
BaA	Blount silt loam, 0 to 3 percent slopes
Br	Bourbon sandy loam
BtA	Broms fine sand, 0 to 3 percent slopes
Cd	Chesterburg fine sandy loam
ChB	Chetopa fine sand, 2 to 6 percent slopes
CnC	Chetopa fine sand, 6 to 12 percent slopes
CnD	Chetopa fine sand, 12 to 18 percent slopes
Cs	Connecticut sandy loam
CoA	Cowpea silt loam, 0 to 2 percent slopes
CoB	Cowpea silt loam, 2 to 6 percent slopes
Dv	Duneland
Ed	Edwards muck, drained
EsA	Etowah loam, 0 to 2 percent slopes
EsB	Etowah loam, 2 to 6 percent slopes
Fs	Forsyth muck, leamy
Gf	Gifford fine sandy loam
HaA	Hanna sandy loam, 0 to 3 percent slopes
Hb	Hickory sand Aquic
Hc	Homer loam
Hm	Houghton muck
Hn	Houghton muck, drained
Id	Ida muck, drained
Im	Ida muck, leamy fine sand
Ma	Ida muck, leamy fine sand
Ms	Ida muck, leamy fine sand
MsB	Ida muck, leamy fine sand, eroded
MsC	Ida muck, leamy fine sand, eroded
MsD	Ida muck, leamy fine sand, eroded
MsE	Ida muck, leamy fine sand, eroded
MsF	Ida muck, leamy fine sand, eroded
MsG	Ida muck, leamy fine sand, eroded
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MsI	Ida muck, leamy fine sand, eroded
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MsO	Ida muck, leamy fine sand, eroded
MsP	Ida muck, leamy fine sand, eroded
MsQ	Ida muck, leamy fine sand, eroded
MsR	Ida muck, leamy fine sand, eroded
MsS	Ida muck, leamy fine sand, eroded
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MsU	Ida muck, leamy fine sand, eroded
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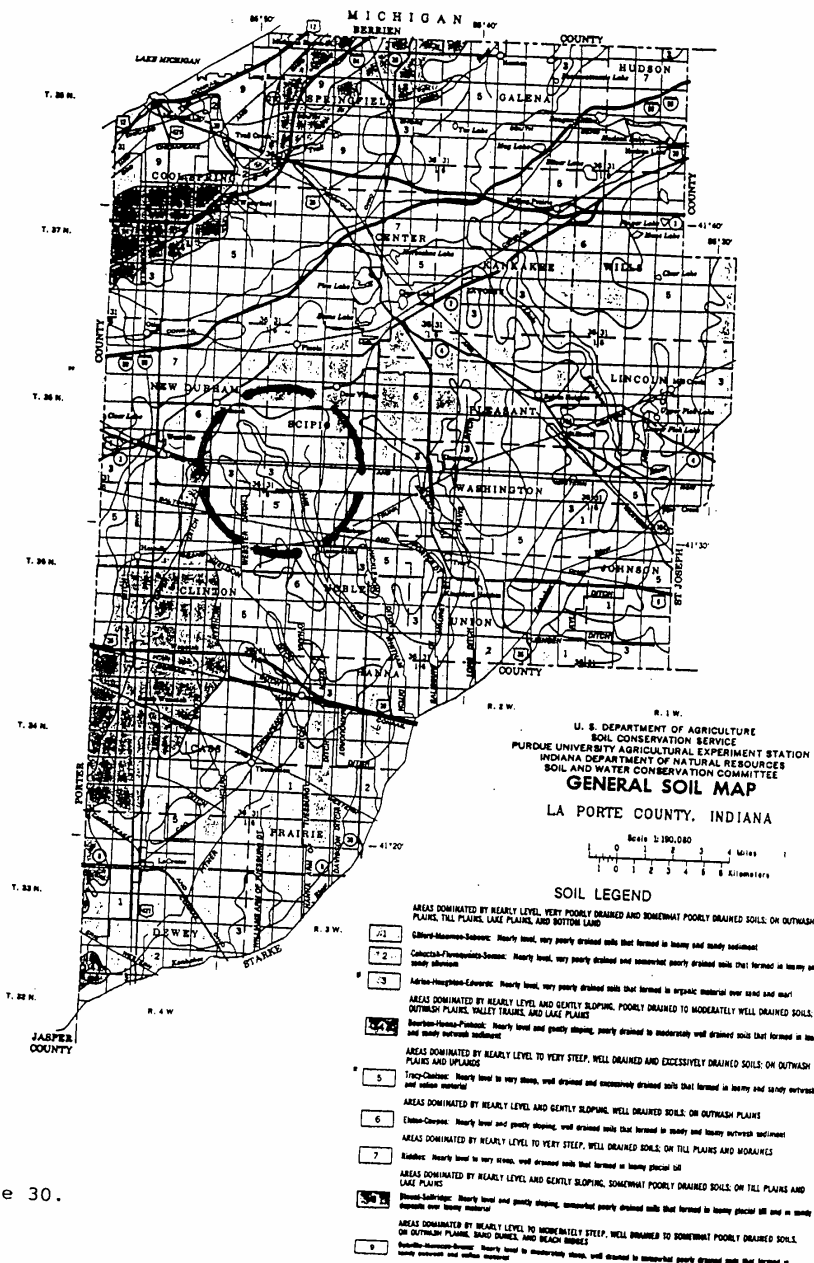


Figure 30.

Highly Erodible Land (HEL)

The purpose of identifying areas containing HEL is to display the origin of potential sediment sources so that the study may target areas of general concern. Using the Soil Survey of LaPorte County by the USDA-SCS issued in 1982, data provided by the local SWCD and SCS offices, soils of the HEL designation were mapped as shown in Figure 31.

The following highly erodible soils occur within the watershed and have been highlighted in table 5.

TcC2*	Tracy sandy loam, 6 to 12 percent slopes
ChC*	Chelsea fine sand, 6 to 12 percent slopes

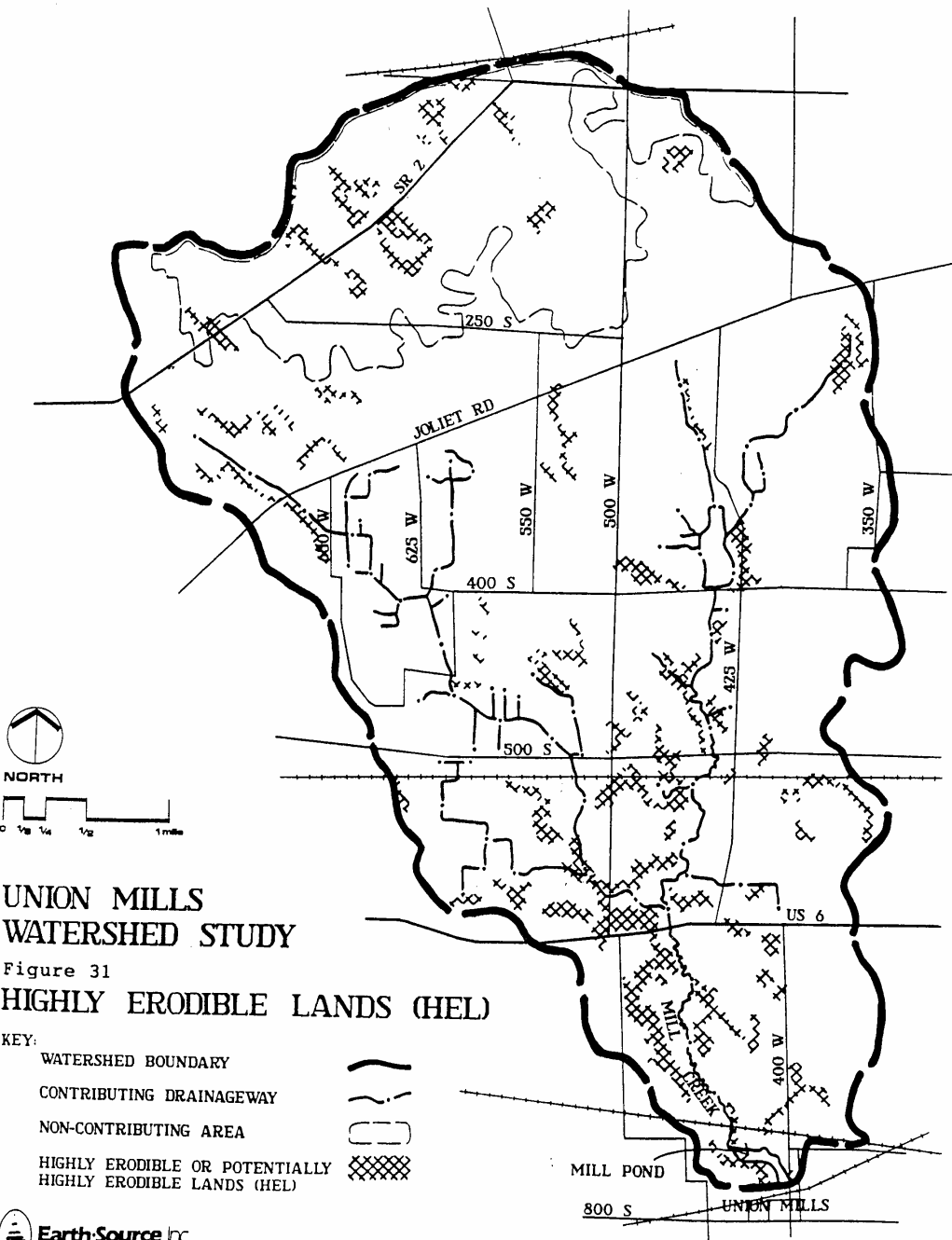
* Highly erodible land

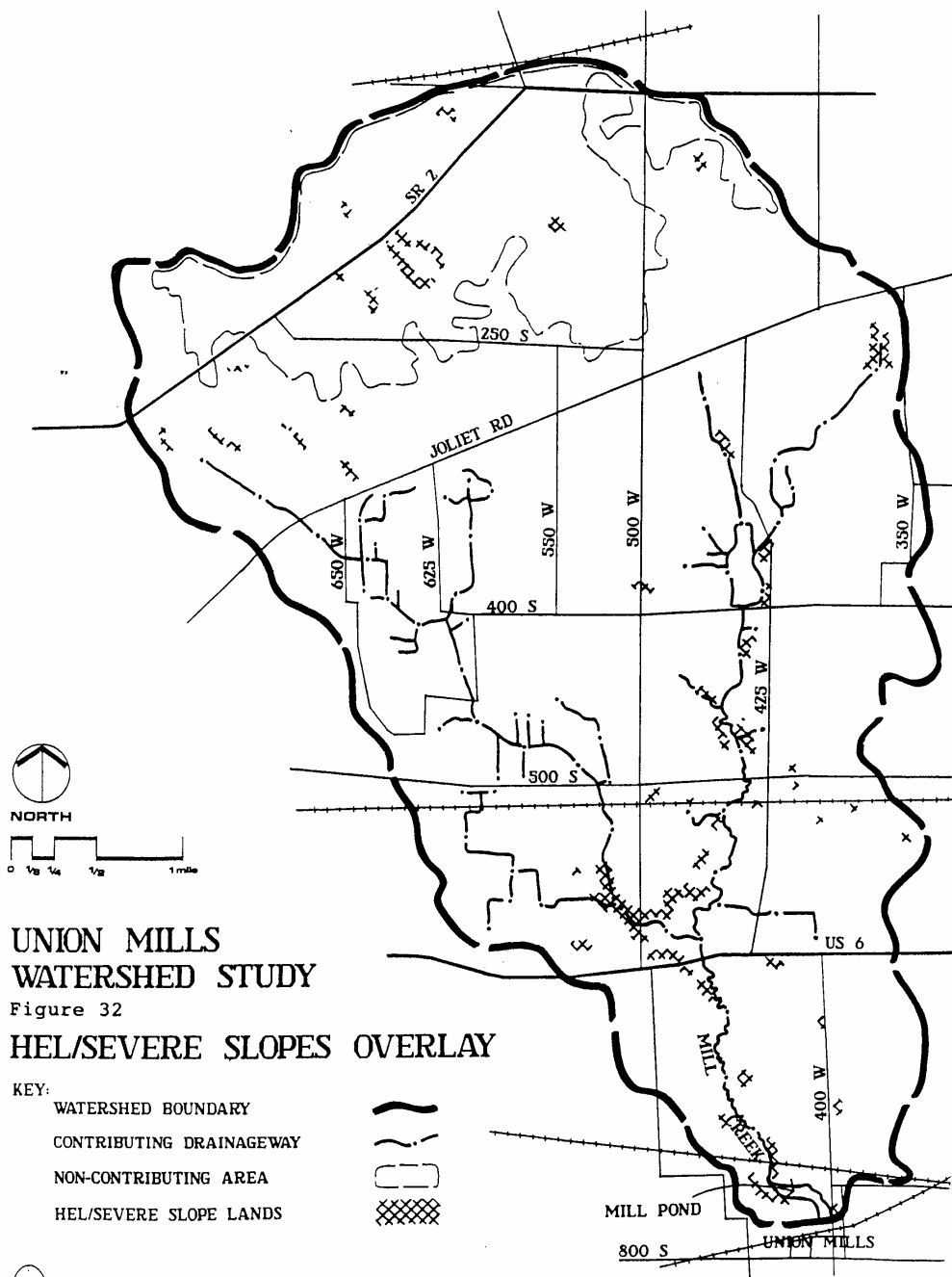
Table 5. HEL and Potential HEL soils of the Union Mills watershed.

HEL or potential HEL was found to comprise 07 % (apx 935 ac) of the Union Mills watershed. The study area was then further divided to determine contributing and non-contributing HEL. Approximately 74 % (693 ac) of the total HEL are considered to be directly contributing to Mill Pond. Target sediment sources were located using the HEL map and will be discussed further in the recommendations and conclusions section of this report.

HEL/Severe slope overlay

The intent of this overlay (Figure 32) is to further emphasize the areas of the watershed where severe erosion problems are likely to occur. The majority of the areas defined in the HEL/severe slope overlay are adjacent to open ditches which facilitate the transport of eroded soils to the Mill Pond. For this reason, those areas present the greatest sedimentation threat to the Mill Pond. Every effort should be made to enlist those lands into CRP or related land treatment programs. It is apparent from the HEL/severe slope overlay and various watershed tours during the course of this study, that the majority of the critical erosion areas of the watershed have not been fully addressed. The central reaches of the watershed contain lands where critical erosion problems are likely to occur. These lands should not be in agricultural crop production without utilizing soil conservation tillage practices.





Erosion: Causes and Prevention

Erosion of soil is primarily caused by the force of raindrops striking the ground, and, secondly, by the force of water flowing in rills or channels. As rain falls on unprotected ground it breaks small particles of soil free. These soil particles are then carried away by sheets of water. Naturally, as the intensity of rainfall increases, velocity and volume (flow) of runoff increases, thus potential soil erosion increases.

Types of soil erosion probable or noted in the Union Mills watershed:

1. Raindrop (or splash) erosion due to the impact of rain on unprotected land.
2. Sheet erosion or overland flow causes exposed soil to be suspended by the action of the flowing water, this is common on sloping to nearly level unprotected land.
3. Rill and gully erosion is the result of concentrations of runoff water in riverlates. Rill erosion may cut several inches into the topsoil, gully erosion resulting from unmaintained rills or drainages may cut several feet into the surface.
4. Streambank and channel erosion causes a scouring of stream bottom and undercutting of stream banks.
5. Wind erosion, similar to sheet erosion, is caused by the turbulent force of the wind over unprotected land.

The erosion potential of a given area may be determined by four criteria: 1) soils; 2) surface cover; 3) topography; and 4) climate.

An understanding of soils, the factors involved in making soil more susceptible to erosion, i.e.) soil texture, soil structure, soil content of clay or organic material, and soil permeability. Maintaining adequate surface cover, either in the form of vegetative cover or crop residue, is important in reducing soil loss.

The realization is that soil is a valuable resource, and particles are difficult and expensive to recover once erosion has begun.

Prevention is easier than correction!

Useful concepts in erosion prevention and control:

- a. Maintain natural vegetative cover wherever possible.
- b. Protect sloping areas. Vegetation is difficult to establish and maintain on eroded slopes.
Row cropping should be done perpendicular to slope.
- c. Divert runoff from severely sloping areas.
- d. Break up long slope lengths by multiple cropping or landscaping when natural cover is not maintained.
- e. Stabilize drainage areas immediately following any construction or "maintenance".
- f. Leave natural buffer areas along streams and ditches.
- g. Stabilize stream bank or ditch escarpments.
- h. Utilize sediment ponds below feed lots and "open" sloping lands.
- i. Construct and maintain sediment control structures prior to construction of any lake or waterfront development.

Hydrology

The Union Mills watershed is a sub-drainage basin of the Kankakee River Basin. According to the LaPorte County Soil Conservation Service, the main water supply comes from ground water.

The watershed of Union Mills receives an average annual precipitation of 42.4 inches with a five year standard deviation of 11 inches. July tends to be the wettest month with an average precipitation of 4.9 inches. On average, February is the driest month with a precipitation mean of 2.3 inches. Mill Creek exhibits a drainage gradient of 1.89 m/km.

Water regimes, according to the 1979 Cowardin et al classification system, range from intermittently to permanently flooded. Seventy four percent of the wetlands associated with the Union Mills watershed are of seasonal water regimes (table 6). Ninety percent are small, less than 10 acre, Palustrine wetlands (table 7). The upper portion of the watershed contains numerous wetland depressions, some of which remain undrained. The majority of the wetlands in the Union Mills watershed however, have been channelized, dredged or otherwise modified to expedite drainage. Ultimately, these modifications impair the wetland's natural ability to cleanse the water of sediments, nutrients and pesticides.

The past ten years have witnessed an extraordinary revival of interest in the drainage and reclamation of our non-arable swamp lands, and it is safe to predict that no movement will be attended with more beneficial or far reaching consequences.

1914 "Drainage and Reclamation of Swamp and Overflowed Lands"
Bulletin No. 2, Indiana Bureau of Legislative Information

Table 6. Union Mills water regime characteristics.

<u>Palustrine</u>	<u>Occurrence</u>	<u>% Totals</u>
< 10 acres	13	10
> 10 acres	124	90
Totals	137	100
<u>Type</u>		
Forested	19	14
Emergent	104	76
Scrub \ Shrub	14	10
Totals	137	100
<u>Water Regime</u>		
Temporary	46	33
Seasonal	74	55
Semi-permanent	17	12
Totals	137	100

Table 7. Union Mills watershed wetland classification.
An explanation of wetland class may be found in
appendix A.

<u>By Class</u>	<u>> 10 Acres</u>	<u>Percent Class</u>	<u>Percent Total</u>	<u>< 10 Acres</u>	<u>Percent Class</u>	<u>Percent Totals</u>
PFOA	0	0	0	4	3	3
PFOB	2	15	2	0	0	0
PFOC	0	0	0	13	11	9
PFOF	0	0	0	0	0	0
PEMA	0	0	0	23	18	17
PEMB	1	8	1	9	7	6
PEMC	1	8	1	53	43	37
PEMF	1	8	1	16	13	12
PSSA	1	8	1	1	1	1
PSSB	4	30	3	1	1	1
PSSC	3	23	2	4	3	3
PSSF	0	0	0	0	0	0
Totals	13	100	11	124	100	89

Natural Features

The Union Mills watershed falls within the Kankakee Sand, Natural Region as classified by Homoya. This Natural Region is comprised of prairie and savanna natural community types. The prairie communities may be characterized by the presence of big and little bluestem (Andropogon spp.), switchgrass (Panicum virgatum), porcupine grass (Stipa spartea), prairie talinum (Talinum rugospermum), primrose violet (Viola primulifolia) and various sedges (Carex spp.). The savanna communities are comprised of many of the same prairie species as well as black oak (Quercus velutina), goat's rue (Tephrosia virginiana), bracken fern (Pteridium aquilinum) and dryland blueberry (Vaccinium vacillans).

The Union Mills watershed is somewhat unique in that it contains one of the few remaining natural stream sections in Indiana, Mill Creek. The Mill Creek community may be characterized by the presence of cattails (Typha latifolia), broad leaf arrow head (Sagittaria latifolia), various bladder-worts (Utricularia spp.), St. John's-wort (Hypericum adpressum), pondweed (Potamogeton spp.), coontail (Ceratophyllum spp.) and marsh marigold (Caltha palustris). Various fauna of the Mill Creek area include whitetail deer, red fox, raccoon, ornate box turtle, massasauga rattle snake. Also included are great blue heron, several species of songbirds and raptors, as well as established populations of waterfowl. The Mill Creek supports a diversity of fishes such as sunfishes, basses and pike. Trout have also been reported in the Mill Creek however, this is not confirmed.

Techniques useful in preserving these natural features include:

- a. Avoid relocation of natural stream channels
- b. Avoid building close to wooded ravines or stream banks.
- c. Preserve natural vegetation adjacent to water areas.
- d. Avoid construction in, or drainage of, wetlands.
- e. Avoid the use of on-site septic systems near the lake or near drainages where there is potential for saturated soils.

Sediment Removal Option (Mill Pond)

Sediment removal (dredging) would be the principle method to improve the recreation and aesthetic (cosmetic) value of the Mill Pond. This method is presented only as an option in order to illustrate the scope. The concept in Figure 33 illustrates a possible approach to sediment removal from the bottom of the Mill Pond. Some of the design characteristics are as follows: a) Maintain shoreline perimeter of existing vegetation a minimum of 25 feet wide. This will limit shoreline erosion and slumping. b) Maintain the shallow existing segment of wetland on the northwest shore to filter and divert main flow toward central pond channel. This would also protect the desired open water area along the west shore. c) Remove bottom sediments to an optimal depth of ten feet where open water is to be maintained. Eight feet of depth may maintain open water or become a part of the transition zone. d) Sediments are to be removed after drawdown, under as dry conditions as possible. e) Sediments should be removed to a suitable location isolated from the Mill Pond, if not out of the watershed. Erosion prevention of this material must be of highest priority. f) Some of the dredged material could be used to reinforce the existing embankment. Final design and engineering must take into account the characteristics and integrity of the old structure during drawdown. g) Retain other shallow areas, and provide island(s) for fish and waterfowl habitat.

Sediment Removal Cost Considerations

Parameters considered:

- 1) Under drawdown conditions.
- 2) Work done in the dry.
- 3) 10 foot desired depth to maintain open water

If, nine feet of sediment is removed over 84,900 square foot.
28,300 cubic yards \$198,100. excavated, hauled & spread*

If, eight feet of sediment is removed over 61,500 sqft.
18,200 cubic yards \$127,400. excavated, hauled & spread*

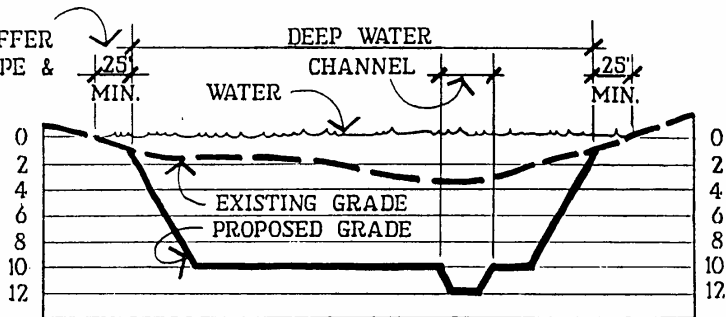
If, seven feet of sediment is removed over 74,025 sqft.
19,200 cubic yards \$134,400. excavated, hauled & spread*

* Based on assumed cost of \$6-8 per cubic yard of material.

Approximately five to six feet would be the minimum amount of excavation required to obtain open water. It may be possible to do the sediment removal in phases by area. The sediment removal option should be pursued only after significant upstream sediment/nutrient controls* have been implemented.

* Upstream controls either in the form of the constructed options or specific watershed management practices.

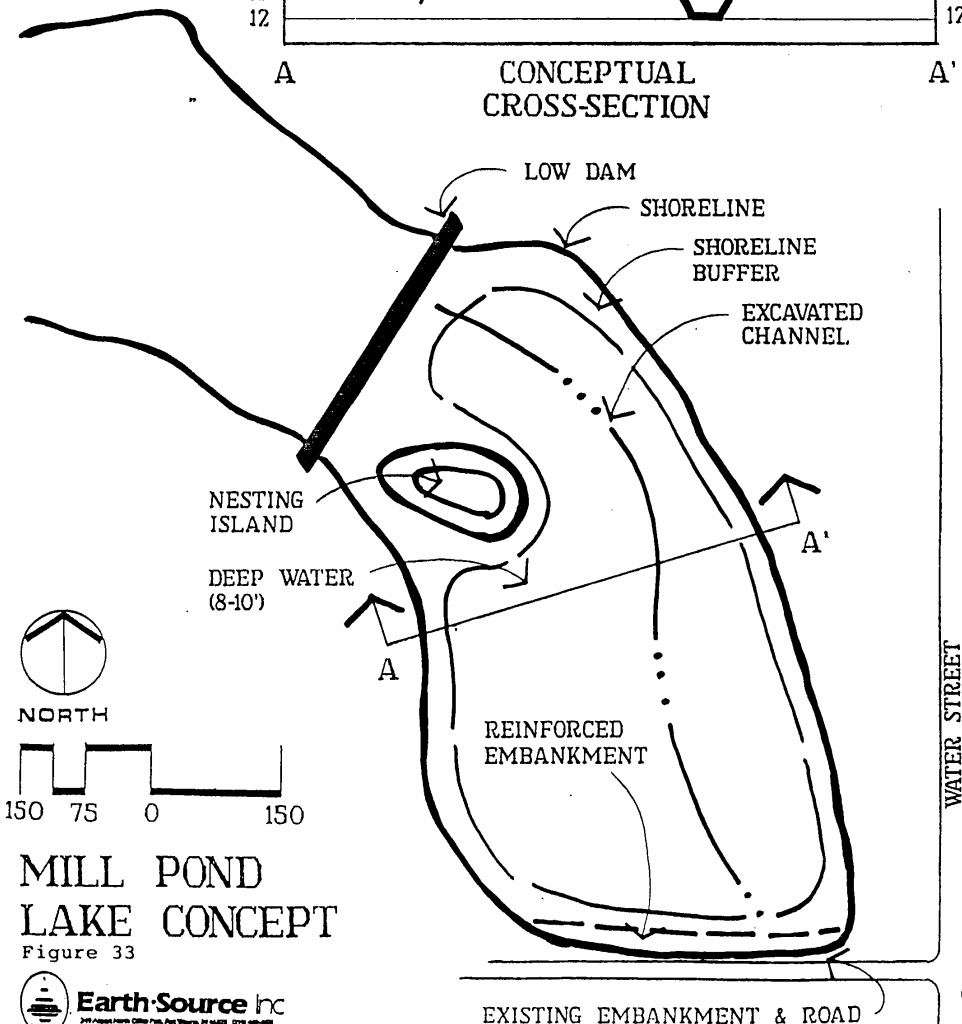
SHORELINE BUFFER
MAINTAIN SLOPE &
VEGETATION



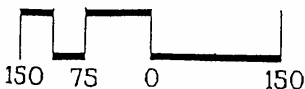
A

CONCEPTUAL CROSS-SECTION

A'



NORTH



MILL POND LAKE CONCEPT

Figure 33



Earth-Source Inc.

240 Airport Avenue, Suite 100, Fort Worth, TX 76102 (817) 441-0000

Constructed Options

During the course of the Mill Pond watershed study, a primary objective was to identify potential nutrient/sediment trap target sites. Some of the criteria in selecting these sites were: location, topography, flow rates, practicality, current land use, and sediment/nutrient loading characteristics of the drainage basin.

Five sites have been targeted for constructed options (Figure 34). Detail 'a', 'b', 'c', 'd', and 'e' are located above (upstream) the Mill Pond, on Mill Creek. Each site is intended to reduce the flow of sediment and nutrients from the watershed into Mill Pond. All sites are privately owned, and are on regulated drains or wetlands. In selecting these sites, the entire length of the drainage basin was evaluated by the criteria mentioned above. These sites were then evaluated individually. In each case, their close proximity to the Mill Pond should produce the most effective results. It must be understood that while the constructed options are considered to be the most effective methods of controlling the flow of sediments and nutrients into Mill Pond, they are not the final solution. Several upland sediment/nutrient sources were discussed in the watershed tour section of this report. Although beyond the scope of this work, a detailed study of upland sources should be identified and corrective measures implemented. The La Porte County Soil and Water Conservation District has committed to providing more detailed assistance with watershed issues.

Project Descriptions:

Detail 'a', Mill Creek

Detail 'a' would divert a portion of Mill Creek into a maintained sediment trap located north of the Baltimore & Ohio Railroad grade (Figure 35). The site would involve excavation of an abandoned railroad lime pit, construction of a diversion baffle, and bank stabilization. Implementation of this project would decrease the flow of sediment and sediment bound nutrients into the existing wetland and Mill Pond, as well as decreasing the velocity of water entering the existing wetland. The result is increased detention time and nutrient and sediment removal.

*check
on
fair*

Detail 'b', 'c', and 'd', Mill Creek wetland

Detail 'b', 'c', and 'd' (Figures 36, 37, and 38) in combination would divert flow from the existing channel above Mill Pond into the wetland. This would provide increased filtering of the sediment/nutrient rich flow of Mill Creek by utilizing the natural wetland on both sides of the channel. This detail would be most effective when incorporated with detail 'e', by redirecting the flow from the channel and

decreasing velocities at the head of the wetland. This project would require earthwork within the wetland and agency reviews. An island/ baffle complex of earth work is suggested.

Detail 'e', Mill Pond/wetland boundary

Detail 'e' (Figure 39) is the most ambitious project to be considered. To attain the most effective sediment/nutrient removal, a large "contact" area is necessary. The construction of a low head dam structure at the pond/wetland boundary would sufficiently raise the water elevation above the existing channel, into the wetland. Studies of soils; hydrology; engineering; and specific topography would be necessary to determine the maximum elevation and width of the low head dam structure. The existing water depth is shallow in this area, and would not require a great amount of fill to achieve an embankment.

Priority of constructed options

1. Detail 'a'. Study of the pond and related sediments indicate that the flow of nutrients entering the pond has been relatively constant over recent years. The major factor responsible for increased weed growth in Mill Pond is attributed to increased sedimentation. As the pond "fills in" a greater area is capable of supporting aquatic weeds. Therefore, decreasing the flow of sediment into Mill Pond must be of highest priority.

2. Detail 'e'. A wetland is one of the most effective sediment/nutrient removal systems known. The excellent wetland complex above the Mill Pond is short circuited by the channel which meanders through it. In order to divert flow into the wetland, flow must be diverted from the channel. Construction of a low head water control structure at the wetland/pond boundary would provide effective long term utilization of the wetland with minimal impact.

3. Detail 'b', 'c', and 'd'. This project is intended to divert flow from the channel to the wetland at the upper end. The project would provide semi-long term utilization of the wetland, however the wetland would rechannelize in time.

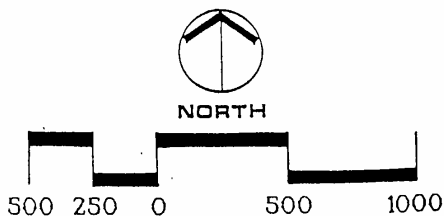
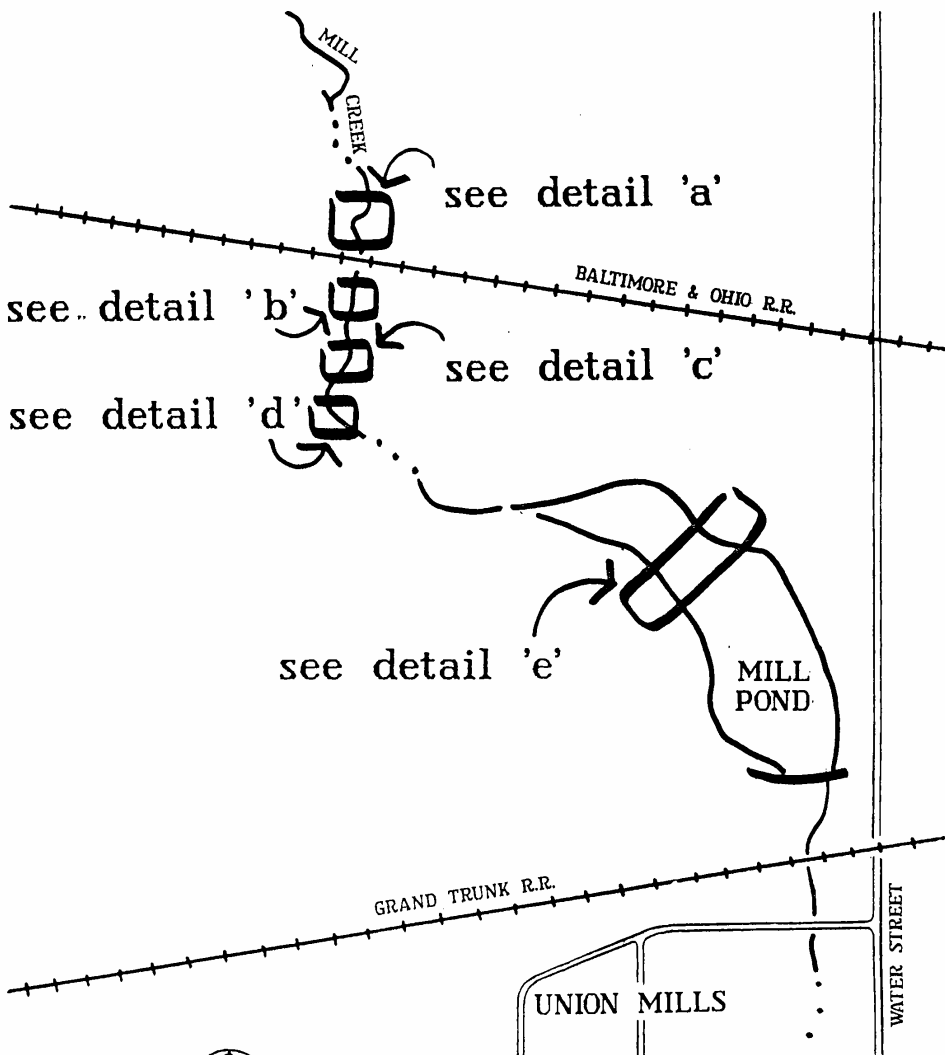
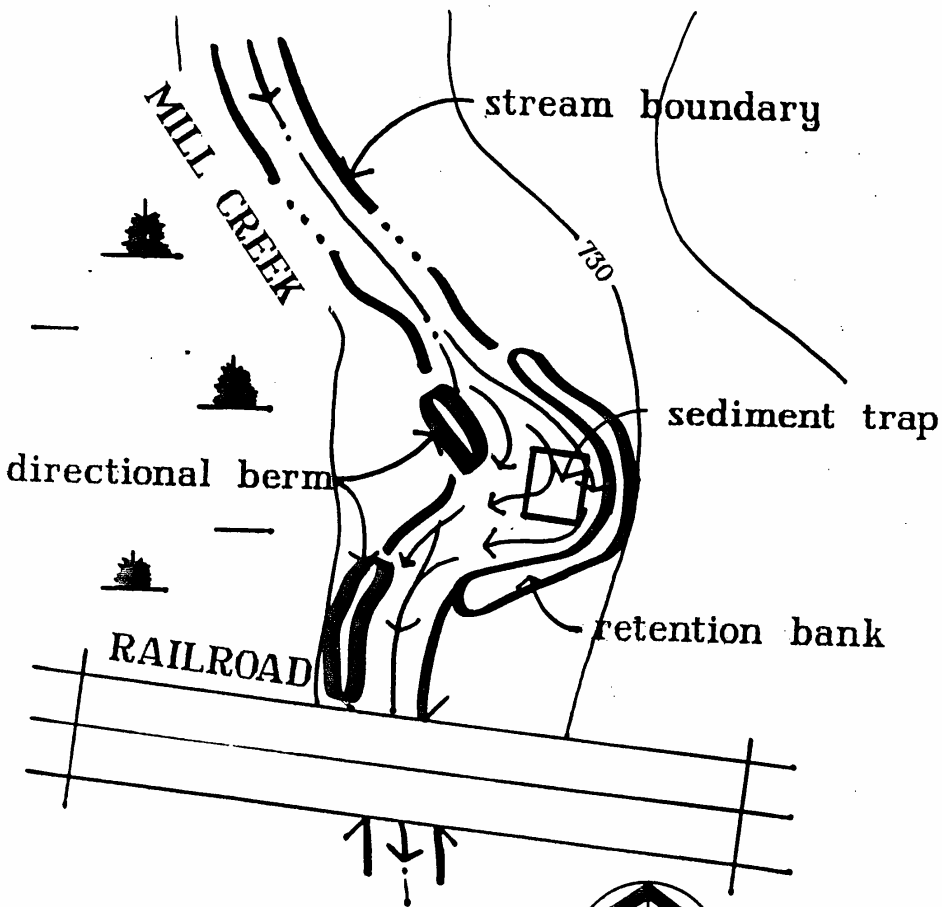
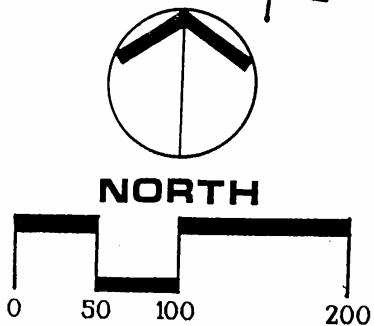


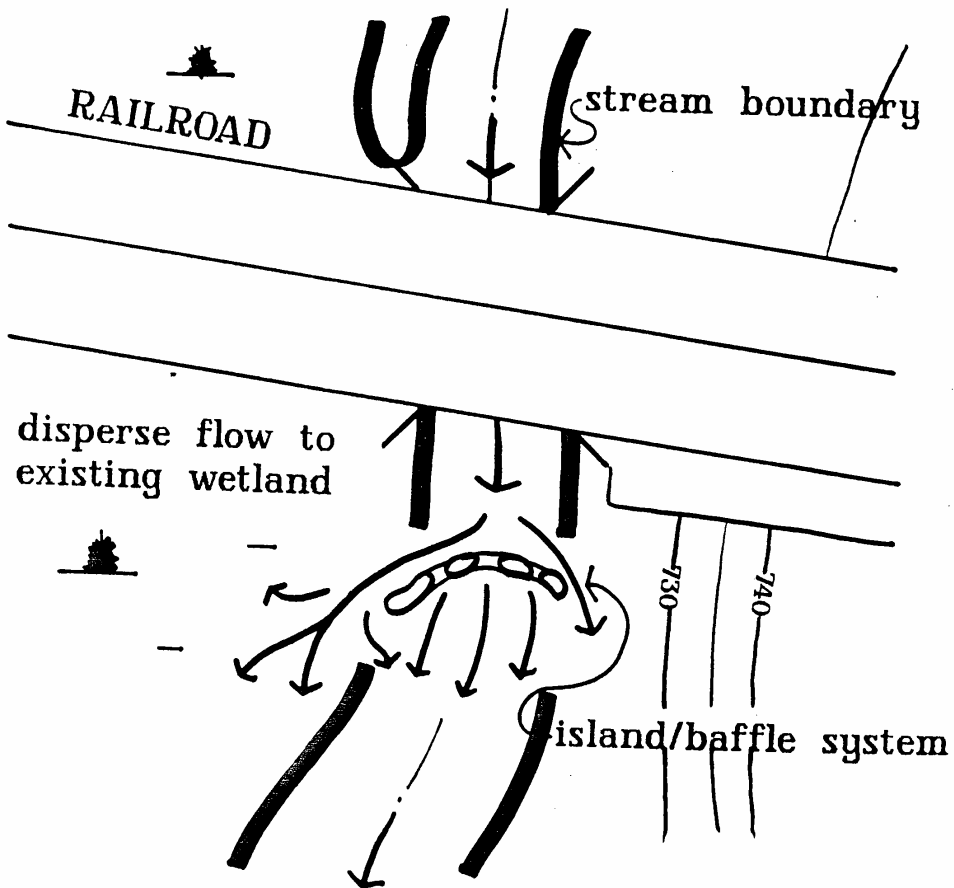
Figure 34
**UNION MILLS
 WETLAND CONCEPTS
 LOCATION MAP**



UNION MILLS
WETLAND CONCEPT
detail a

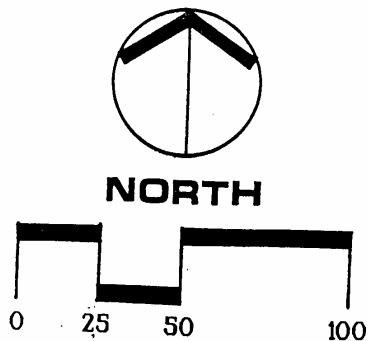
Figure 35

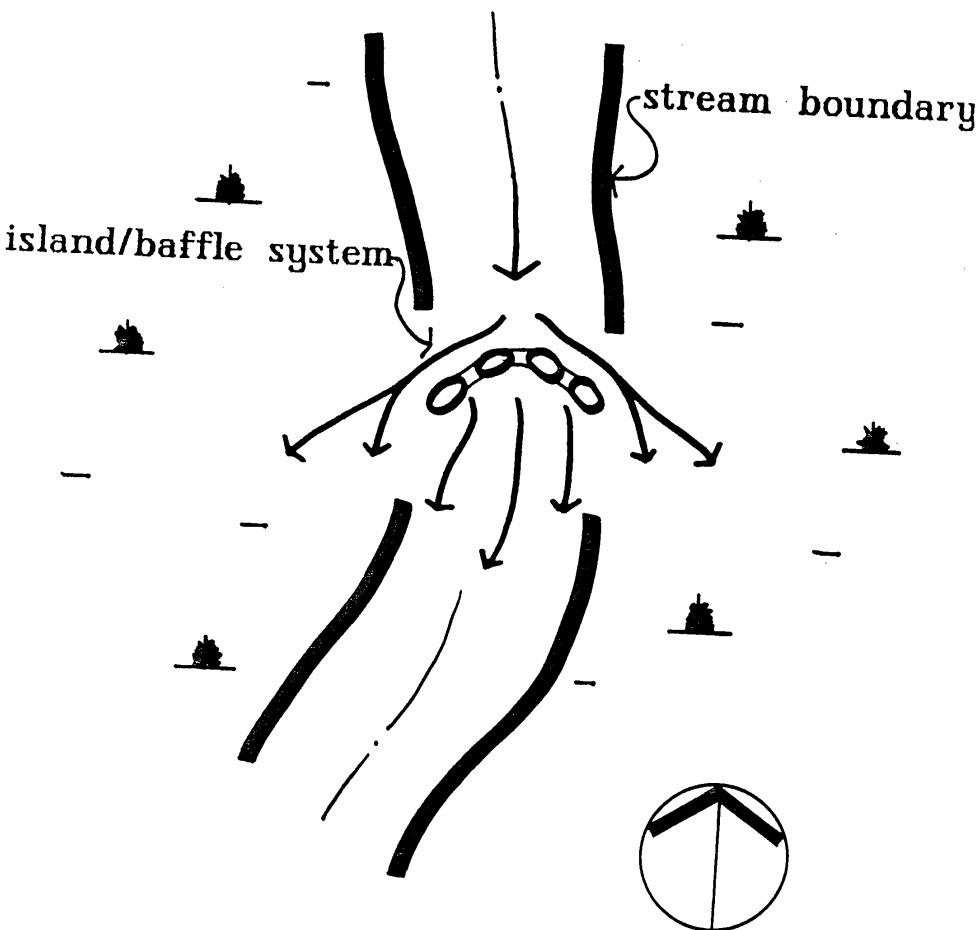




UNION MILLS WETLAND CONCEPT detail b

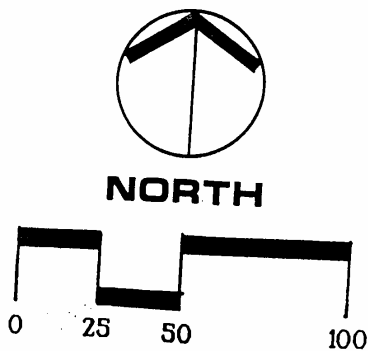
Figure 36

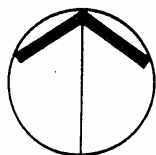
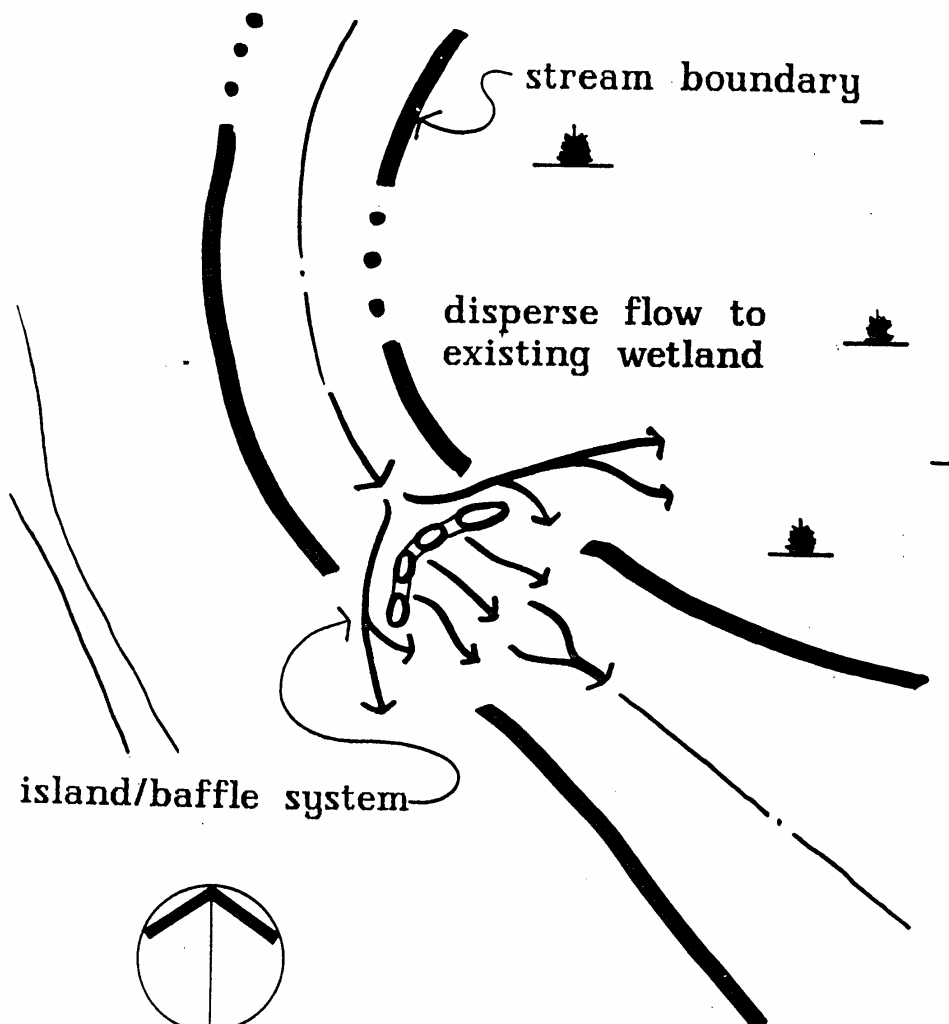




UNION MILLS
WETLAND CONCEPT
detail c

Figure 37





NORTH



**UNION MILLS
WETLAND CONCEPT
detail d**

Figure 38

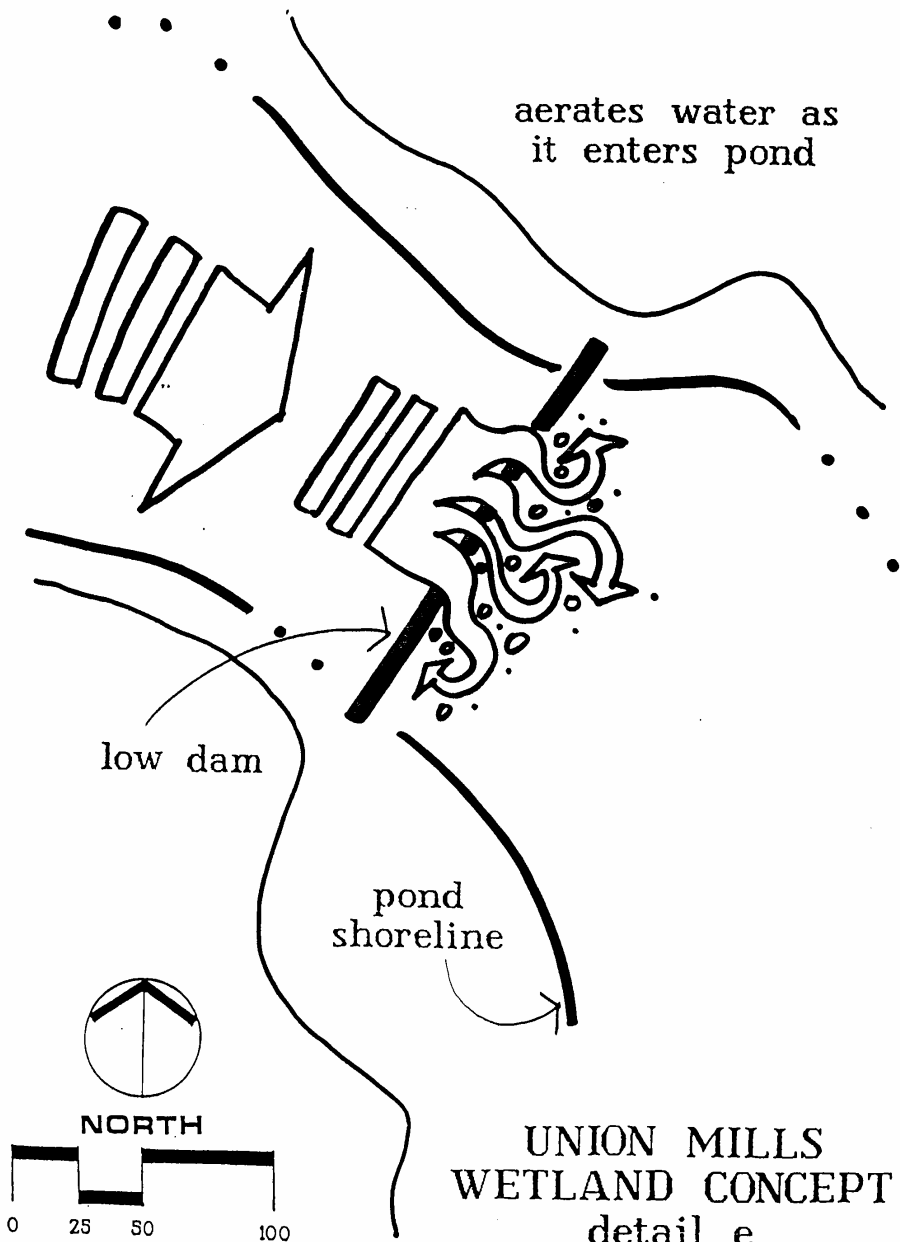


Figure 39

Constructed Wetland Habitat

A great deal of potential exists in the design of sediment/nutrient control structures to increase the overall wildlife habitat and production capabilities for the Union Mills area.

Primary fisheries production in the Mill Pond could benefit greatly by increased functional wetlands. Virtually all sport fish production is dependent on wetlands, either for spawning, cover or planktonic food production. Pike and sunfish are major benefactors of increased wetland spawning area. They spawn in the wetlands and then return to the lake proper.

Increased wetlands will draw waterfowl away from areas of moderate human use. Productivity is likely to increase while the "nuisance factor" decreases. Song birds are drawn to wetlands for a number of reasons: nesting structure provided by persistent emergent vegetation (cattails); security cover; and food production. Species such as the Great Blue Heron, Yellow Rail, Great White Egret, and Yellow-headed Blackbird (which are all state threatened, rare or of special concern) will locate near wetlands for many of the same reasons as their avian counterparts.

Fur-bearing animals like beaver, mink and muskrat depend on wetlands mainly for food, security cover and den sites.

Musk rats would likely be the first fur-bearer to colonize a constructed wetland. These prolific mammals do well in areas with have low water flow and emergent aquatic vegetation such as cattails. If muskrat den/foraging activity strays from or damages the constructed wetland and wetland structures it may become a nuisance, therefore, populations would require careful monitoring.

The mink is one of the most prized furbearers associated with wetlands. The habitat requirements of the mink are similar to those of the muskrat with one exception, the mink is a carnivore, thus, mink population will usually mirror changes in muskrat population.

The beaver is another valued furbearer likely to colonize a constructed wetland in the Mill Pond area. Again, if den/dam building activity strays from the constructed wetland it may become a nuisance, therefore, beaver populations would also require careful monitoring.

In summary, a constructed wetland is capable of increasing and supporting a diverse number of inhabitants. It should be noted that a constructed wetland is also constructed habitat. By design, these areas may attract species of special interest, through planned inclusions of required habitat.

Sediment and Nutrient Removal

In order to quantify the effectiveness of a control structure or constructed / enhanced wetland in removing sediments and nutrients, it is first necessary to develop a flow model. Flow models are used to determine a particular hydraulic characteristics for a given site at a given point in time. In this case, a flow model would be used to determine the surface loading rate (SLR). The SLR is used to derive the position of a particle (sediment) within a system at a any given point. With this information, a settling time can be predicted for particles entering a system based on distance and time rather than the specific gravity of a select range of particulates. The predicted sediment removal can then be determined by comparing the settling time needed to remove X amount of sediment from a system with the actual retention time for the system.

Nutrients are removed from a system in two basic ways: Nutrients can be removed by biotic processes in which they are utilized by plants and bacteria or; nutrients can be removed by physical processes. Nutrients often travel through a system bonded to particulate matter, thus, as sediments are settled out, so are the nutrients attached to them.

Extensive stream monitoring and construction design would be necessary to predict the actual amounts of nutrients transported thru a system or to quantify the amount removed by a specific control structure. It is possible, however, to relate nutrient removal efficiencies from other structures designed by Earth Source Inc. At the Wilson Ditch site (near Culver, Indiana) for example, Mean total phosphorous was reduced 90%, while mean total nitrogen (nitrate/nitrite) was reduced 85% during the 1988 summer monitoring program. Mean total phosphorous was reduced 60% and mean total nitrogen was reduced 65% during the 1988 winter monitoring program. Similar nutrient removal rates could be expected for the constructed/enhanced wetland sites for the Union Mills area.

Permitting

Beyond property ownership, many governmental agencies may have jurisdiction over private property or land use. For example, drainage may be regulated by the County Surveyor. Water issues, particularly construction in a floodway, is regulated by the Indiana Department of Natural Resources, Division of Water. The United States Department of the Army, Corps of Engineers regulate discharge of dredged or fill material in wetlands. The Corps of Engineers, and the Indiana Department of Natural Resources, will require permitting for each of the proposed constructed options above the Mill Pond, and for dredging of Mill Pond. Earth Source Inc. must be consulted in the case that one or more of these options is selected for final design so that a wetland delineation and all the proper permits may be pursued.

Conclusions & Recommendations 3.

THE MILL POND: CONCLUSIONS AND RECOMMENDATIONS

Water Quality

It is most unfortunate that past water quality data for Mill Pond were unavailable. It is clearly documented with photos, however, that the pond was relatively weed free during the mid 1950's and has only recently changed to complete weed domination of the water column. Current measurements of physical and chemical parameters place the pond in the Indiana Department of Environmental Management lake classification category of worst water quality (Class Three). Since this scheme was developed solely on parameter estimates from water, inclusion of the phosphorus incorporated within the weed tissue would indicate an even worse water quality condition.

Wetland Nutrient Retention

The current wetland trapped approximately 14-17% of the total phosphorus entering Mill Pond via Mill Creek during May and June 1989. Phosphorus values in wetland sediments were approximately three time greater than sediments of pond cores also suggesting retention of this important nutrient within the wetland. Unfortunately, most of the flow of Mill Creek is within the channel and little of the total volume flows through the fringing wetland. It is recommended that a secondary dam be built at the wetland-pond boundary both to facilitate sheet flow of water through the wetland and to incorporate the stream channel into part of the wetland. By expanding the wetland area and spreading stream flow through it, nutrient and sediment uptake should be increased resulting in a significant reduction in the loading of both parameters to Mill Pond. Such an alteration in the wetland should not affect watershed drainage patterns.

Basin Infilling

Siltation in Mill Pond has become so serious that <1% of the total pond area is currently >4 feet. Approximately 36% and 28% of the pond area is <1 foot and 1-2 feet, respectively, and therefore of little recreational value. It is suggested that current weed problems are not the result of a major increase in phosphorus and/or nitrogen loading to the pond in recent years, but rather a direct consequence of basin shallowing via silt to a point that plant growth is no longer light limited and therefore able to colonize the entire lake bottom. Pond sediments are >80% inorganic matter, a situation found only in situations experiencing extreme siltation from the surrounding watershed. Our core

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note
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studies indicated that the current wetland is ineffective at trapping silt from entering the pond and that the greatest deposition of silt is within the central portion of Mill Pond proper. We found no evidence to indicate that the annual input of silt to the pond has altered significantly within at least the past 40-50 years.

Drawdown

We experimentally simulated pond the effect of drawdown on sediment phosphorus release at five sites in Mill Pond. Estimates of phosphorus release from sediments even after complete desiccation and reflooding were up to four times greater than observed in pond water during spring and summer 1989 suggesting that sediments are an important source of this important plant nutrient in the Mill Pond system. Sediment phosphorus release was greatest in wetland sediments and decreased downstream into the pond proper. Additional evidence for the importance of sediments as an internal phosphorus source was obtained from our water quality monitoring data. Sediment release in Mill Pond increased total phosphorus concentrations in water of the outlet by 17-60% over values of water entering the pond. While our investigations clearly demonstrated that sediments are an important nutrient source in Mill Pond, it is equally clear that drawdown will not reduce phosphorus recycling in the pond.

Dredging

Sediment profiles for percent water, inorganic and organic matter as well as total phosphorus were constructed for cores collected from three sites. The dry weight percentage of inorganic matter increased from the wetland to the pond proper, while total phosphorus decreased. Values for the latter were approximately three times greater in wetland than pond cores. Given that no marked stratigraphic variation was noted for any parameter in the three cores, it is suggested that dredging will not significantly reduce sediment phosphorus concentrations. Dredging is recommended, however, as a good management approach for Mill Pond in that deepening the basin will increase open water habitat for fish as well as reduce plant growth via light limitation. Our experience elsewhere has shown that deepening to at least 10 feet will likely significantly reduce plant infestation in the lake. Our examination of pond sediments for heavy metal and organic chemical contaminants failed to demonstrate any significant level of pollution that would constitute a problem regarding land disposal of dredged material.

THE WATERSHED: CONCLUSIONS AND RECOMMENDATIONS

First, it is critical that some nutrient/sediment trapping system be constructed immediately above the Mill Pond for some short-term stabilization. The constructed options and priority of these projects are discussed in the text. Second, land treatment practices need to be evaluated in detail, especially animal waste handling, pasturing, filter stripping, and tillage. This soil type may be ideally suited to no-till or mulch-till farming. These methods of conservation tillage would also help retain fertility, as well as reduce erosion. Any management practices or construction in the Mill Pond will be short lived unless the excessive load of sediment from the watershed is reduced. Third, open ditching should be evaluated in detail. Abandonments may be possible, wetland restorations may be suggested, and certainly bank stabilization is warranted. Excavated sediment traps throughout the Mill Creek system may also be a part of the solution.

I. General recommendations:

Encourage preservation of remaining upland forest, wetlands and upland depressions.

Avoid relocation of natural stream channels.

Avoid building close to wooded ravines or stream banks.

Preserve natural vegetation adjacent to water areas, such as remaining in lake wetlands at stream inflows.

Avoid construction in, or drainage of, wetlands.

Maintain natural vegetative cover wherever possible.

Stabilize drainage areas immediately following any construction or "maintenance". Quick vegetative cover and streambank protection is essential to erosion control.

II. Residents of Union Mills:

Monitor surface runoff from town of Union Mills to the Mill Pond.

Monitor septic system drainage (if any) to Mill Pond. Residences must take the responsibility of maintaining their own waste disposal systems. Drain fields should be inspected regularly and septic tanks should be pumped on a regular schedule.

Avoid the use of on-site septic systems near the pond or near drainages with a potential for saturated soils.

III. The Watershed:

Construct sediment traps on ditches in section 5.

Look for wetland restoration opportunity in section 32.

Monitor effect (if any) of heavily grazed areas adjacent to Mill Creek.

- .. Monitor stream segments of the entire Mill Creek system to discern more precisely where water quality problems originate. Test parameters should include: conductivity, alkalinity, total suspended solid, pH, total phosphorus, ortho phosphorus, total nitrogen, and nitrate-nitrite.

Stabilize stream banks. Filter strips would be helpful.

Consider Constructed Options as described in that Section of this report.

Those areas defined as HEL/severe slope areas should not be in active agriculture (row cropping) or under development without extensive erosion control consideration. Leave natural buffer areas or filter strips along streams and ditches. Efforts should be made to enlist HEL into CRP or related land treatment programs.

Stabilize stream bank or ditch escarpments.

Protect sloping areas. Vegetation is difficult to establish and maintain on eroded slopes.

Row cropping should be done perpendicular to slope. Break up long slope lengths by multiple cropping or landscaping when natural cover is not maintained. Divert runoff from severely sloping areas.

Utilize sediment ponds below feed lots and "open" sloping lands.

If sediment removal from Mill Pond is pursued, the dredged material could be re-incorporated into local agricultural lands. The material is very high in nutrients and organic matter. This would be an excellent method of replacing top-soil lost to erosion, as well as an economical method of disposing of the dredged material. A soil scientist and/or the USDA-SCS should be involved in this matter.

Appendix

APPENDIX C

Various Conservation Practices and Values, and Degree of Difficulty for Implementation

Conservation Plans	Required by the 1985 Farm Bill
Land Adequately Treated	Normal
Conservation Cropping System	Difficult
Critical Area Planting	Moderately Difficult
Crop Residue Management	Difficult
Diversions	Difficult
Farmstead Windbreak	Normal
Feedlot Windbreak	Normal
Field Windbreak	Normal
Field Border	Very Difficult
Grade Stabilization	Moderately Difficult
Grassed Waterway	Difficult
Holding Ponds & Tanks	Easy
Livestock Exclusion	Moderately Difficult
Livestock Watering Facility	Moderately Difficult
Minimum Tillage	Difficult
Pasture & Hayland Management	Difficult
Pasture & Hayland Planting	Difficult
Pond	Easy
Recreation Area Improvement	Normal
Sediment Control Basin	Difficult
Stream Channel Stabilization	Moderately to Very Difficult
Streambank Protection	Moderately Difficult
Stripcropping	Very Difficult
Surface Drains	Difficult
Terraces, Gradient	Very Difficult
Terraces, Parallel	Very Difficult
Tile Drains	Difficult
Tree Plantings	Very Difficult
Wildlife Habitat Management	Moderately Difficult
Woodland Harvesting	Moderately Difficult
Woodland Improvement	Difficult

Adapted from Final Report on the Black Creek Project;
Allen County (Indiana) Soil and Water Conservation District.

PRACTICE	EFFECTIVENESS	LONGEVITY	CONFIDENCE	APPLICABILITY	POTENTIAL NEGATIVE IMPACTS	CAPITAL COST	O&M COST
Addition of Tertiary Treatment	E	E	E	E	E	F	F
Construction of Sedimentation Basins at Inlets to Lake	G	E	G	G	G	F	F
<u>AGRICULTURAL PRACTICES</u>							
—Conservation Tillage	F-E	G	G	G	F	F	F
—Contour Farming	F-G	P	F	G	E	E	E
—Pasture Management	F-G	E	E	G	E	E	E
—Crop Rotation	F-G	G	G	G	E	E	E
—Terraces	F-G	G	G	G	E	F	G
—Animal Waste Management	E	E	E	E	E	F	F
—Grass Waterways	E	E	G	G	E	G	E
—Buffer Strips	E	E	E	E	E	G	E
—Diversification of Runoff	G	G	F-G	F	E	F	G
<u>CONSTRUCTION CONTROLS</u>							
—Erosion Control Ordinance	E	E	E	E	E	E	E
—Runoff Control Ordinance	E	E	E	E	E	E	E
—Field Inspections	E	E	E	E	E	E	E
Legend: E = Excellent G = Good F = Fair P = Poor							

SOURCE: The Lake and Reservoir Restoration Guidance Manual, USEPA

APPENDIX E

The following is a list of Federal, State and local agency contacts which may be useful in obtaining further information or permit requirements.

EPA
Wetland Protection Section
401 M Street SW
Washington, D.C. 20460
(202) 382-5043

EPA, Region V
230 S. Dearborn Street
Chicago, IL 60604
(312) 353-2079

US Army Corps of Engineers
20 Massachusetts Ave., NW
Washington, D.C. 20314
(202) 272-0169

US Army Corps of Engineers
Louisville District
P.O. Box 59
Louisville, KY 40201-0059
(502) 582-5607

US Fish & Wildlife Service
18th & C Streets, NW
Washington, D.C. 20240
(202) 343-4646

US Fish & Wildlife Service
Bloomington Field Office
718 N. Walnut Street
Bloomington, IN 47401
(812) 334-4267

IDNR
Division of Water
2475 Directors Row
Indianapolis, IN 46241
(317) 232-4160

IDEM
Office of Water Management
Chesapeake Building
105 South Meridian Street
Indianapolis, IN 46206
(317) 232-8476

IDNR
Div. of Soil Conservation
FLX1 Building
Purdue University
West Lafayette, IN 47907
(317) 494-8383

IDNR
Div. of Fish & Wildlife
607 State Office Building
Indianapolis, IN 46204
(317) 232-4080

La Porte County Surveyor
Courthouse
La Porte, IN 46350
(219) 326-6808

USDA-SCS, La Porte County
97 West 18th Street
La Porte, IN 46350
(219) 362-6633

Earth Source Inc. (permitting)
349 Airport North Office Park
Fort Wayne, IN 46825
(219) 489-8511

TYPICAL SEDIMENT/ NUTRIENT SOURCES...

...that contribute to decline of environmental values in a watershed.



EarthSource Inc.

